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English Department Studies:

Reading the Texture of Reality

Chaos Theory, Literature and the Humanist Perspective

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Acknowledgements

A brief flurry of clichés: Night is drawing in, the cold air tightening its grip, and my tired legs have that slight tremor on every step. But after a long journey, including those few frustrating (even scary) misdirected scrambles in difficult terrain, I finally spot the cabin on the opposite bank of the river. Off with the boots and with a final adrenalin rush I wade across the freezing water, drop my rucksack on the porch and step in the warm glow of the stove.

This journey, however, has been neither solo nor unsupported. My colleagues at the Department of English should know by now what that community means to me, and they are all included under a warm and fuzzy blanket of thanks. A few individuals must, however, be singled out for explorer-style bearhugs. My supervisor and Graduate School boss, Professor Bo Pettersson was there at the beginning, listening to my breathless account of a research plan as he raced across Rautatientori to catch a train, and I have benefited from his wide reading and generosity in numberless (and less rushed) discussions ever since. Docent Mark Shackleton, as well as sharing his family name with one of my all-time heroes, initiated me to the world of Tom Stoppard, and if the tone of this dissertation is still too trenchant, it is no fault of his. Dr Joseph Flanagan's throw-away comments have taught me more about argumentation and the analysis of poetry than any books could have, and Dr Maria Salenius has solved many a thorny problem for me by being eminently sensible (and forcing cups of coffee down my throat). Dr *in spe* Howard Sklar, even though he beat me to it in our race to finish, receives thanks for being the perfect pacer, and never failing to encourage and inspire a lagging colleague. I also wish to thank all the other staff members and fellow students whose presentations of their own work and commentary on mine has taken place in the Department's seminars over the years.

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Helsinki, November 2008

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Introduction

> The opposite of a correct statement is a false statement. But the opposite of a profound truth may well be another profound truth.
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> Niels Bohr to Werner Heisenberg

In Tom Stoppard's play *Arcadia* (1993) Bernard the literary scholar and Valentine the mathematician have an on-going feud over the value of their respective fields of interest. Their verbal duels are a fine example of the age-old argument over whether science and literature can be meaningful. Bernard berates science for only providing meaningless factual details: he 'can't think of anything more trivial than the speed of light' (*A* 61), and he feels that cosmology is pointless compared to the beauty and insight in Byron's poetry. Valentine, on the other hand, voices the excitement generated by new scientific knowledge, and has the satisfaction of seeing Bernard's pet theory destroyed by one of those trivial factual details (*A* 88). In the play the two opinions find a balance, and both poetry and the non-human physical world engage the human imagination. If Bernard argues that all relevant knowledge is self-knowledge (*A* 61), the elements of chaos theory in the play show that scientific knowledge can be vital to gaining an understanding of our own place in the physical scheme of things, which makes it a natural part of attaining true self-knowledge.

Like Stoppard, many literary critics and theorists have commented on the discoveries of chaos theory, but unlike the playwright, many of them have taken those discoveries to mean that we live in a universe where shape, coherence and knowledge are illusions. Even many critics writing on *Arcadia* seem to assume that since it thematises chaos theory, it must be a play about fractured time, lost meanings and the absurdity of the human condition. But Stoppard has, in fact, created a play in which chaos theory symbolises precisely the ways in which human beings *can* gain

knowledge of the world and make that knowledge meaningful in their particularly human context.

This study arose from the need to explain a group of literary works that have clearly been influenced by chaos theory, but which equally clearly fall outside the categories and descriptions suggested by previous theoretical approaches to literature and chaos theory. Although these previous publications have made important contributions to understanding the complex ways in which order and disorder have been conceptualised in postmodern culture, their emphasis on the disordered end of the spectrum makes them unable to accommodate works that, while obviously referring to the methods of chaos theory and the systems it studies, also engage the order found in the seemingly complex, the possibility of coherent meaning despite the noise in the message, and the physical reality that lurks behind human sign systems. These three conceptual clusters are the foci for this study and form the backbone of the discussion in chapters 2 through 4.

Most of the literary discussions on chaos theory focus on the relationship between the individual mind and what surrounds it – whether other texts or other beings, fictional or real. From the mid-1900s onwards the way Western culture has understood that relationship has been influenced by the idea of physical existence as information. After the Second World War the epistemological implications of the theory of relativity, quantum mechanics and Claude Shannon's work on information and entropy created a paradigm of uncertainty. This paradigm displaced the overly optimistic views of the reliability of information and, once human beings were demoted from their special status as the pinnacle of creation, it was seen to explain not only the essential functions of the physical universe, but also that of human language and consciousness. All this formed what Patricia Waugh (2005: 243) has called the 'scriptoral metaphor': a view of existence as a flow of information that moves inevitably towards its own extinction. Many authors have seen chaos theory in the light of this paradigm. I would argue, however, that there is another dimension involved, one that, instead of concentrating on a universally appli-

cable model of information, emphasises the various interconnected physicalities which exist on the level of human experience. Where the paradigm of information has continued to influence the neo-Darwinist descriptions of human beings as ruled by their genetic programming, and the poststructuralist theories of all-encompassing textuality (Waugh 2005: 242-244), what I call the humanist perspective describes embodied human minds and their interaction with a universe which is physical, though to a large extent culturally mediated. Analyzing the reception of chaos theory in literary studies offers us a way of bringing these two paradigms into clearer focus.

The title of my study reflects this difference in emphasis between previous approaches and the one presented here. Not only does this work aim to give an overall description of those perspectives to chaos theory that have been adopted within the humanities in general and literary studies in particular, but it also aims to point out the specifically humanist themes that authors have found in chaos theory, but which the literary critical and theoretical discussion has to a large extent ignored. Thus, in this context 'humanist' refers firstly to the area of scholarship that examines human beings and human meanings instead of purely physical phenomena. Chaos theory may be a set of ideas developed in mathematics and physics to explain physical systems, but it also creates resonances in certain concepts dealt with in the humanities. Secondly, the term 'humanist' refers to specific approaches in the humanities, approaches that have their starting-points in what some would see as old-fashioned conceptualisations of artistic form, identity and reality.[1] While aware of the fraught history of the term and the criticism it has received, I suggest that it can still serve to describe the perspective discussed

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[1] In this context 'humanism' does not refer, for example, to the discussion about the relative positions of Christian religion and secular humanism (either in the form of Enlightenment rationality or the current theories of biological determinism), nor to the more specifically North American debate between Humanism and what has been called the Moral Majority (see Lamont 1949/1982).

here. What I see as particularly humanist elements in that perspective are an interest in durable forms, in human identity, and in building ideas of representation on some version of epistemological realism. In addition, within the context of the accumulation of knowledge the term carries ideological implications by focusing on communal effort and a respect for other voices.[2] All of these aspects of humanism have received criticism, starting from the anti-classical theories of artistic form, and running all the way through to the deconstruction of the subject and of linguistic reference.[3] Without wishing to return to the control-centred, essentialist and backward-looking positions that humanism has occupied in the past (in particular through European imperialism), my aim in adopting the term in spite of its ideological baggage is to show that chaos theory is being used specifically as a way of opening up new approaches to issues bracketed by anti-humanist critique. The authors and scholars discussed here try to go beyond the structuralist and poststructuralist theories by combining stability with dynamics in order to try and conceptualise a humanism that could accommodate the critique. Thus this study employs 'humanism' to denote a particular attitude towards structure, identity and reality, without implying that it is either a synchronically or a diachronically consistent philosophical position.[4]

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[2] Humanism has been connected to an interest in coherent form particularly in the context of Renaissance humanism and its attention to classical proportions. For humanism associated with a view of identity as a unitary phenomenon and a source of agency see e.g. Said (2004: 41-43), and with epistemological realism see e.g. von Wright (1977).

[3] For overviews of anti-humanist critique see Soper (1986) and Davies (1997: 35-71, 127-135).

[4] Even though I am keen to emphasise that the thinking associated here with humanism has undergone changes and is still continually developing, I do not want to be drawn into dubbing the approach a 'new humanism', since that term has itself already been associated with various interpretations, including the 'problematization of man' that took place during the Enlightenment (von Wright 1977: 15), the 1920s argument for a return to the classics in the American universities (Said 2004: 17-18) and what Georg Lukács (1983: 28) has described as the view of 'man as a product of himself and his own activity in history'. On 'posthumanity' see section 3.1.

The phrase 'texture of reality' in my title comes from a chapter title in Ian Stewart's popular science book *Does God Play Dice?* (1989/1997), where it refers to the fractal forms discovered in nature by chaos theory. In this study the phrase refers not only to those forms of reality, but also to their textual representations. The authors considered here do not see reality as textuality but as a physical realm which is accessible to the human mind. This access is achieved not only through the physical sciences, but also through individual human experience, at least in so far as the mind is able to develop a feel for the texture of reality – to intuitively form a sense of the dynamics that are expressed in physical things. Moreover, the texts discussed in this thesis attempt to re-enact in language the forms discovered by chaos theory: the self-similarity of fractals and the infinite but constrained loops of strange attractors. These are the textures that my readings attempt to make felt to the reader.

As the opening epigraph of this introduction suggests, although this thesis has its roots in my own sense that the dominant interpretation of chaos theory in literary studies is incomplete, I do not mean to imply that it is completely misguided. The question is whether to emphasise complexity or simplicity; whether authors and scholars are more interested in the varieties of intricate works and interpretations, or in the larger patterns of shared elements appearing in literature and in human minds. Chaos theory can provide metaphors for both approaches, and in the hands of some authors it preserves the balance between the two. Thus I set out to delineate the humanist perspective to chaos theory not in order to eclipse the previous interpretations, but with the aim of shedding light on that end of the chaotic spectrum which has within literary studies (though not in literary works) received less attention. Further, I aim to clarify the theoretical positions that form the background to the whole discussion and are perhaps the reason why the humanist aspects of chaos theory have remained so much out of sight.

Enter Chaos Theory

During the 1960s and 1970s scientists in various fields were working on both natural phenomena and mathematical abstractions which, though relatively simple systems, did not behave as predicted by the calculations. They eventually developed new mathematical formulae to deal with these discrepancies, and collectively these methods became known as chaos theory. Examples of chaotic behaviour have now been found in weather patterns, stock-market price fluctuations, dripping taps, the motion of asteroids and the erratic eye-movements of schizophrenics. In such systems discrepancies do not just appear briefly before settling down into an equilibrium, but instead one minute change sparks another, and another, until the overall behaviour of the system bears no resemblance to the original predictions. But it is important to note that even while embracing the unpredictability of natural phenomena, chaos theory by no means denies determinism.

Thus scientific chaos does not, despite the common sense of the word, mean randomness, but nonlinearity; it does lack predictability, but it has discernible form. Furthermore, while disorder does increase in the universe as a whole (as thermodynamics showed by discovering entropy in the nineteenth century) chaos theory demonstrates that simple formulae, expressed as iterated algorithms, may also create pockets of negentropy: they give rise to infinitely complex and unpredictable structures. The point is that the universe may still be winding down, but it is not simply breaking down the structures we already recognise. Instead, it is also constantly creating new, dynamic structures. In this way chaos theorists set aside the most pessimistic reactions to entropy and emphasise the presence of *emergent complexity*: 'Somehow, after all, as the universe ebbs toward its final equilibrium in the featureless heat bath of maximum entropy, it manages to create interesting structures' (Gleick 1987/1988: 308).
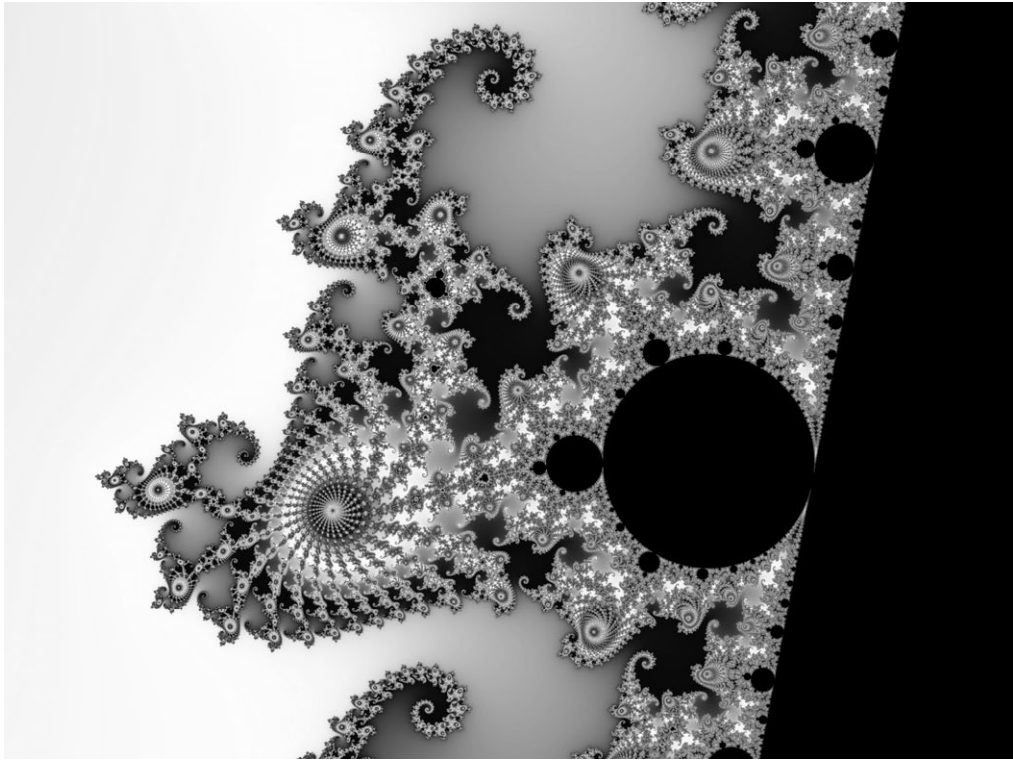
Fig. 1. A detail from the boundary of Mandelbrot Set, the most famous of fractals.[5]

The central concepts in chaos theory have to do either with such complex dynamics of change or, in particular, with the geometrical presentations of those dynamics. *Fractals* are geometric shapes whose dimension is neither 1 (line), 2 (plane) nor 3 (solid), but, for example, 1.26 (snowflake) (Stewart 1989/1997: 205). The most frequently mentioned characteristics of fractals are their infinite depth (successive zooming to smaller and smaller details only reveals ever more details) and their *self-similarity*, the way the shapes revealed by the zooming strongly resemble one another from level to level.

Another geometrical way of envisioning the dynamics of chaos are *strange attractors*. An attractor is defined as whatever shape a system's activity settles down to (Stewart 1989/1997: 99). The reason why chaotic systems have attractors deemed strange is

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[5] 'Mandel zoom 03 seehorse'. Created by Wolfgang Beyer with the programme *Ultra Fractal 3*. Wikimedia Commons. <http://commons.wikimedia.org/wiki/Image:Mandel_zoom_03_seehorse.jpg>. Accessed 25.9.2008.

that their activity does not settle into either a single state (a point on a graph) or a limit cycle (a loop), but instead creates a trajectory that is, in fact, a fractal. The lines of a strange attractor split into an infinite number of further lines, indicating a behaviour that is in some sense settled (it does not leave the area defined by the attractor) but is, at the same time, infinitely variable within those settled parameters.
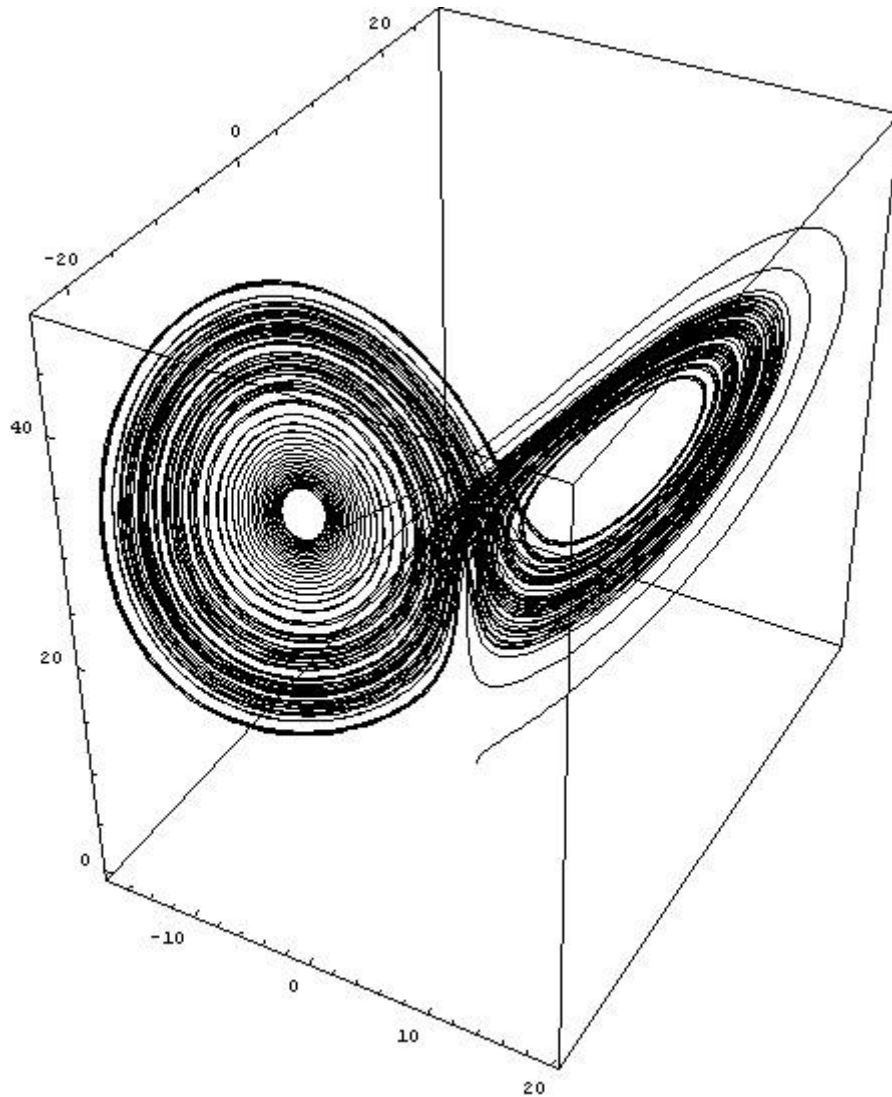
Fig. 2. The strange attractor by Edward Lorenz, known as the butterfly attractor.[6]

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[6] 'Attracteur étrange de Lorenz (1963)'. Created by user Zweistein. Wikimedia Commons. <http://commons.wikimedia.org/wiki/Image:Lorenz.jpg>. Accessed 30.10.2008.

These four concepts: emergent complexity, fractals, self-similarity and strange attractors will recur in several contexts in this study and form the core of the view of chaos theory presented here. One further note of clarification on terminology should be made: *chaos theory* here refers to the collection of mathematical methods and physical theories that aim to explain chaotic behaviour, and *chaos* to the behaviour of the systems thus studied.

The boom in the study of chaos took place during the 1980s and 1990s, as is shown by Weingart and Maasen's (1997: 467-471) analysis of the number of occurrences within the Science Citation Index (SCI) between the years 1974 and 1996. During the twenty-two-year period the number of documents with 'chaos' or 'chaotic' in their titles rose from 23 to 1,008. Scientific popularisations began to appear fairly quickly after the formulation of the theory in professional articles (Paul 2004: 37-42), culminating in two particularly influential books: science journalist James Gleick's best-selling *Chaos: Making a New Science* (1987/1998), which remains the most often cited source for authors, poets and playwrights, and Ilya Prigogine and Isabelle Stengers's *Order Out of Chaos: Man's New Dialogue with Nature* (1984), a more philosophically oriented work by a Nobel-prize-winning chemist and a philosopher of science, which has greatly influenced many literary scholars.

On the basis of these and other works, chaos became a popular new concept during the 1990s and it appeared both in dozens of works of literature and in literary criticism and theory.[7] Clearly, chaos theory is not the first scientific idea to leave its mark in the literary field. The effects of, for example, the theory of evolution, thermodynamics and quantum mechanics have been extensively studied (see e.g. Wilson and Bowen 2001, Beer 1983/2000 and

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[7] The MLA database lists 'chaos theory' as a subject term for the first time in 1988 for N. Katherine Hayles's *SubStance* article on Michel Serres. Subsequently the number of books or articles per year averages around ten, the strongest years being between 1994 and 2002. An early peak is formed by Hayles's collection *Chaos and Order* in 1991 (16 occurrences), as its chapters are listed separately in the database.

Strehle 1992). Like these earlier notions, chaos theory found resonances in the cultural atmosphere of its time. As N. Katherine Hayles (1990) has argued, the themes of unpredictability, fractal diffusion and reflexivity were well in place in postmodern works of literature by the time chaos theory was articulated in the sciences, thus making the theory an attractive analogy for literary scholars. The popularity of chaos theory in literary studies, however, is also closely connected with the nature of the disciplines of literature and chaos theory themselves. The appearance of chaos theory in literary studies has had as much to do with the way both of those disciplines were taken as representatives of their respective fields in discussions over interdisciplinary epistemology, as with the vision chaos theory gives of the dynamics of the universe. From C. P. Snow's lecture[8] onwards, literature has been presented as the paradigmatic arts subject, a position due both to the nature of the original debate over the status of English literature in the British educational system in the early twentieth century (Cordle 1999: 13-14), and to the authority of literary theory within more recent, postmodern approaches in the humanities. Chaos theory, on the other hand, with its interest in nonlinearity, unpredictability and margins has often been represented both in popular science and within the humanities as a herald of a paradigm shift towards a new, postmodern science (though chaos scientists themselves have played down such a revolutionary status; see e.g. Gleick 1987/1998: 306-307 and Hayles 1990: 22-23). In other words, many scholars have seized upon chaos theory and literature as a field of study which is assumed to be particularly revealing about the arts and the sciences in general.

The timing of the chaos boom in literary studies can thus be related on the one hand to the postmodern *Zeitgeist* and, on the other hand, to a specific set of popularised books which made

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[8] C.P. Snow's Rede Lecture of May 1959, in which he famously stated that the arts and the sciences are 'two cultures' which no longer understand one another. The ensuing debate, originally between Snow and F. R. Leavis, continued ferociously in the 1990s in form of the 'Science Wars'. See also pp. 19-20.

chaos theory available to non-specialists. Further, the ever-increasing prestige of the natural sciences over the human sciences, and the institutional rewards offered to interdisciplinary projects during the latter half of the twentieth century have also induced many literary scholars to legitimise their work by referring to mathematics and physics. Others have been drawn to chaos theory simply because of their wish to explicate particular literary works in which chaos appears as a thematic and/or structural element. This latter group of texts consists of traditional contextual analysis in which chaos theory simply appears as part of the ideational context of the text, and as such are not representative of interdisciplinarity as it is usually defined. Others use the terminology of chaos theory metaphorically in order to suggest new avenues for literary analysis, or to clarify methods already in place. Some critics and theorists even argue that literary works actually are chaotic systems and that the methods of analysis developed by chaos theory should thus be combined with those currently used by literary scholars. Despite such arguments, however, examples of literary analysis actually using the methods, not just the underlying ideas, of chaos theory have not appeared. This is due to the simple fact that in order to subject a literary text to the methods of chaos theory, its constitutive elements should first be rendered in numerical form – a task which is unsurprisingly difficult.

The single most influential monograph that has been published in the field of chaos and literature is N. Katherine Hayles's *Chaos Bound: Orderly Disorder in Contemporary Literature and Science* from 1990. It is the work to which most others refer, and it established that the relationship between chaos theory and literature is not only worth studying but also diagnostic of much wider issues in postmodern cultural theory. In this particular field Hayles is a figure that cannot be bypassed, not only because of her seminal monograph and the collection of articles she edited the following year, but also because so many of the central issues affecting the field appear in her later work as well, even though not specifically in the context of chaos theory. *Chaos Bound* presents the cultural implications of chaos split in two between the philosophical 'or-

der-arising-out-of-chaos' paradigm, associated with French intellectual circles and Ilya Prigogine, and the 'order-within-the-chaos' paradigm, associated with chaos scientists, the concept of the strange attractor and explanations about the behaviour of real systems. This study traces a similar division, but where Hayles takes literary theory to represent the former view and science the latter, I argue that it is possible to see a contingent of authors and scholars within the field of literature who adhere to what Hayles presents as the natural scientists' conceptualisation of chaos and its implications.

Another book I would like to draw attention to in this introduction is Gordon Slethaug's *Beautiful Chaos: Chaos Theory and Metachaotics in Recent American Fiction* (2000). Slethaug makes a valuable contribution by pointing out that authors have incorporated chaos theory to their texts in several different ways. Many works, he suggests, rely on metaphorical structures based on the ideas of order and randomness. In others the specific concepts of chaos theory are woven into the content of the work, either by creating chaotic structural patterns or through explicit plot references to chaos theory. More rarely the literary works also reflect on their own use of the patterns of chaos and thematise the implications of those patterns for literature and for life. While Slethaug's point that this reflective or 'metachaotic' use of chaos result in the most nuanced use of chaos theory is well made, I would like to qualify his further suggestion that '[o]f the three, the use of metaphor is arguably the least complex or grounded in the specifics of scientific theory, for metaphors are applicable to general expressions of order and disorder rather than to specific manifestations of new theories and practices' (Slethaug 2000: 164). Considering the fact that one of the authors Slethaug focuses on in the volume is John Barth, whose use of metaphors based on chaos theory is both explicit and effective, this statement requires the further clarification that there is a marked difference between metaphors that refer to chaos and order as general concepts and metaphors drawn specifically from the science of dynamical systems. Whereas the former are found in literature

throughout history, the latter are applicable to the 'specific manifestations of new theories and practices' Slethaug calls for, and thus their interpretation calls for a different conceptual context.

The blurring of the traditional metaphorical meanings of chaos and order with the concepts presented in chaos theory is a common problem in literary criticism. A symptomatic example is Philip Kuberski's *Chaosmos: Literature, Science, and Theory* (1994), where the conceptualisation of chaos is split between the theory and the textual analyses. Where the first chapter discusses interesting issues of chaos theory, self-organisation and materiality, the others refer almost exclusively to the older chaos/cosmos dichotomy, even as Kuberski presents various solutions by authors (James Joyce, T.S. Eliot, E.M. Forster, Norman Mailer, James Merrill and Doris Lessing) that go beyond that dichotomy.[9] In contrast, this study concentrates exclusively on the metaphors that arise, not from the traditional opposition between chaos and order, but from the scientific theory which aims to explain chaos in the new sense of dynamical systems and emergent complexity.[10]

My central argument is based on the following two points. Firstly, the theoretical arguments created by literary scholars about the meaning of chaos theory for literature do not accommodate all the literary works which use chaos theory as a conceptual background. Secondly, I believe that the blind spots revealed in these scholars' interpretations of chaos theory match certain questions in current literary theory that have been left unattended, and that the literary works which engage the humanist end of the spectrum of metaphorical possibilities offered by chaos theory point towards new answers to those questions.

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[9] In chapter IV Kuberski (1994: 182, 184) explicitly equates chaos with entropy rather than dynamical systems.

[10] One scholar with an explicit aim of constructing a similar review is Brian Ward, whose PhD thesis from 1998 examines the 'appropriation' of chaos theory in literary studies and discusses issues such as politics, environment and psychology. Ward's sources, however, naturally focus on the fairly early writings on chaos theory and literature and he does not identify the humanist tendencies that are in focus here.

Primary Material

A central issue when choosing primary material for a study of scientific ideas in literary texts is whether the idea should be treated as primary and its appearance in literature as secondary. For many literary critics studying chaos theory and literature has meant showing how the unpredictability and nonlinearity of chaotic systems are reflected both in the plot and the textual elements of individual works. Occasionally these literary works themselves do contain particular interpretations of chaos theory, but most critics seem more interested in either coaxing from them chaos-like characteristics or simply applying methods based on chaos theory to works that have been chosen according to some other criteria. For example Hawkins (1995) and Nemesvari (1997) have followed Hayles (1990: 22-23) in arguing that old texts can be fruitfully analysed using new paradigms, and that comparisons with chaos theory reveal aspects of older works which otherwise would not have been noticed. More recently, Hayles (2000: 2) has also pointed out that a chaotic analysis of a work which does not explicitly discuss chaos theory in its modern form could also be useful in clarifying the philosophical and aesthetic implications of chaos theory – i.e. that the combination of contemporary theory and past literature might discover something new about chaos as a methodological tool rather than just about the literary work which is being examined. This is exactly what the best work on chaos theory and literature has managed to do: to bring together two seemingly very different ideational constructs and produce new information on both.

In this work I aim to reveal something new both about chaos-inspired literature and about the nature of contemporary literary scholarship by analysing literary works and critical texts side by side. As the focus is on tracing the different emphases given to chaos theory in different aspects of literary culture, the literary works I have chosen can clearly be shown to be taking part in the discussion surrounding chaos theory, whereas others which could be linked to the themes of order, disorder, identity or

epistemology, but which make no direct reference to chaos theory or complexity as such are excluded. The works discussed here also incorporate chaos as a thematic element, rather than an incidental cultural detail or plot device. I focus on three authors in particular: British playwright Tom Stoppard (born 1937), American novelist John Barth (born 1930) and American poet Jorie Graham (born 1950). Stoppard's chaos-inspired play *Arcadia* opened in London on 13 April 1993 and immediately became a huge critical and popular success, becoming one of the fastest-selling play scripts in the history of British theatre (Nadel 2002: 447). It is possible, however, that the audience's keenness to buy the text had less to do with their admiration of it than with the necessity of reading the play either before or after seeing it in order to understand exactly what is going on. Stoppard has for years been accused of packing his plays too full of obscure references to aesthetics, philosophy and physics, and although *Arcadia* is more successful in incorporating them into a story than most of his previous works, there is still a lot in the play for the audience to absorb in one sitting. Over the years, *Arcadia* has received considerable critical attention and many critics have also analysed its use of chaos theory. What still remains to be done, however, is to see how Stoppard's interpretation of chaos connects to the larger debate concerning chaos theory and literature – in particular the epistemological and ontological questions discussed in this study.

John Barth has also explicitly incorporated chaos theory into his novels and short stories at least since 1994. Barth has generally been seen, along with authors such as Donald Barthelme, Robert Coover and Thomas Pynchon, as one of the foremost representatives of American postmodern fabulism (Scholes 1967), but his work can also be seen to represent strong humanist tendencies. In his writing chaos theory appears as a metaphor for the interconnectedness of the individual and culture, of present and past voices, as well as for the balance between innovation and recognisable constraints in literary structure. Barth, in particular, can also be seen as an author who uses chaos theory to speak simultaneously about reality and about the ways in which we interpret re-

ality: chaos appears in his works both as a physical phenomenon that links human beings to the universe through self-similar dynamics, and as a metafictional metaphor for the process of meaning-making and story-telling.[11] Barth and Stoppard receive their special place in this dissertation for three reasons: both have published at least one major work that centrally thematises chaos theory; their works are of a quality and complexity that rewards extended analysis; and the issues their works deal with through chaos theory are similar to those that appear in the works of many of the literary theorists, and thereby make the dialogue I hope to set up between literary works and theory possible.

Jorie Graham has been regarded as a poet who, like Barth, is reacting to her own language as she is writing it, and exploring what happens in the gap between her language and the ineffable (Gardner 1999: 1-4). After five collections of poems that appeared between 1980 and 1993, Graham's selected poems, *The Dream of a Unified Field* (1995) won the Pulitzer prize in 1996. Since then she has published five more collections, the latest of which is *Sea Change* from 2008. In her poetry chaos theory appears as one among many other scientific and philosophical theories concerning existence and perception, in particular the theory of relativity, cognitive science and phenomenology. The role Graham gives to chaos theory is closely connected to Barth's and Stoppard's conceptualisations, as her poems represent simultaneously the seething complexity of the physical universe and the difficulty of that act of representation.

In addition to the works by Stoppard, Barth and Graham I refer to a number of other authors as examples of the humanist interpretation of chaos theory. While many works – popular novels especially – suffer from their authors' enthusiasm to educate

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[11] In contrast, even Robert Rebein (2001: 3-7), who argues for a definition of realism that would include the techniques of metafiction, does not include John Barth in the camp of American new realists, but rather counts him, mainly on the basis of Barth's 1967 essay 'The Literature of Exhaustion' as representing the kind of postmodernism that too narrowly concentrates on formal play.

their audience about chaos theory, others present their readers with more intricate experiments on what the implications of chaos theory might be for different areas of human experience. The works discussed here are representatives of a wide variety of genres and traditions, from poetry to metafiction and from short stories to drama, and I believe this variety to support the notion of a general humanist perspective which transcends generic conventions. On the other hand, I hope to have respected the heterogeneity of the material by adopting different techniques of reading for different genres, without, however, losing sight of the main purpose of this dissertation. The texts have been analysed with an eye to their original context, but all in order to reveal how chaos fits into their overall theme and structure.[12]

What is more, it must be kept in mind that not all fiction, drama and poetry which is presented within literary studies as being 'about science' is actually about science as a method of human inquiry at all, but instead about the kinds of natural phenomena that have been revealed or explained by that inquiry. This difference becomes crucial in chapter 4, which discusses literary epistemology and the question of realism. The fact that literary works include scientist characters who proceed to tell their companions (and readers) about the latest break-throughs in dynamical systems theory does not necessarily mean that that work thematises science as such. Often the case is that the scientific ideas are tools by which the book speaks about the reality that the science has revealed. In this way many of the works considered in this dissertation use chaos theory to discuss things other than the differences and commonalities between art and science. These include the complex and unpredictable, yet structured reality that humanity interacts with, the ebb and flow of popular culture, the organisation of societies, or even the search for God. What all the texts share is an ambiguity about the roles of order and randomness. In

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[12] It may also be noted that the only dramatist discussed here is Stoppard, whose works are much more text-centered and under closer authorial control than most contemporary drama (see e.g. Corballis 1984: 10).

chaos theory the authors have found a way of approaching that ambiguity through a scientific model – a metaphor for the complexity of human experience that is simultaneously true about the physical world.

Some of these texts, Stoppard's *Arcadia* in particular, have already received considerable attention, but I hope to show that analysing them together and in the context of the interpretations of chaos theory within literary scholarship will reveal new facets in individual works and clarify an important contemporary intellectual tendency. Lamarque and Olsen (1994: 391), in looking for ways to define which aspects of epistemological theorising can be useful for literary studies, separate two approaches: the reading of 'philosophy *in* literature' (i.e. 'philosophy is subordinated to the purpose and function of literature') and the reading of 'philosophy *through* literature' (i.e. fictive situation throwing light on e.g. a moral problem within a philosophical discourse). My purpose in this study is not to read the fictions purely for information about the implications of chaos theory (chaos theory *through* literature), nor to simply chronicle the ways in which fictions have made use of chaos theory (chaos theory *in* literature). Instead I draw on the literary works to point to certain recurring interpretations of chaos theory in order to clarify theoretical issues, but also use the theoretical issues connected to chaos to form new and hopefully rewarding readings of the works themselves.

The secondary sources I rely on include several popular science books on chaos theory and related sciences. Although I derive from them a basic understanding of the concepts and methods of dynamical systems theory, I do not claim to have formed an expert opinion on chaos theory, nor do I attempt to evaluate the relative merits of the different popular presentations. In choosing what to focus on I take Daniel Cordle (1999: 62-63) as my guide and emphasise that the role of a literary critic engaging science need not (and mostly should not) be an arbiter on the correctness of the various uses of scientific theories:

> science may be distorted as it is popularised or otherwise disseminated, and the writer may in any case misunderstand the sci-

ence. It is unlikely to be the task of the literature-science critic to sort out any such misapprehension, because a list of ticks and crosses against the writer's scientific references is unlikely to be of much interest, and a critic with a literary background may in any case be unqualified for such a task. Certainly, though, the form in which the science is presented is of interest, and a particular 'take' on a scientific idea may well be significant.

Thus I will not be judging whether an author or a literary critic has understood or misunderstood chaos theory, but consider instead the reasons why different interpretations exist.

Interestingly, not only is chaos seen in differing ways in literature, but the popular science presentations of chaos theory also show various 'takes' on the subject, and there are marked differences as to which end of the chaotic spectrum is emphasised. For example, the opposition between Gleick's and Prigogine's books has been much commented on (e.g. Porush 1993). Jack Cohen and Ian Stewart's *The Collapse of Chaos: Discovering Simplicity in a Complex World* (1994/2000), and John Gribbin's *Deep Simplicity* (2004/2005), are both books whose very titles echo the way they stress the simple, underlying rules of the dynamics that appear to us as chaos. My own understanding of the implications of chaos theory draws more heavily on these works than on, for example, Prigogine, for the simple reason that the view of chaos theory I wish to examine in literary works does the same. Thus this study focuses more on discernible shapes than on fragmentation, more on self-similar repetitions and strange attractors than on the endlessly variable depths of fractals.

Background: Theorising Interdisciplinarity

Whenever a theory of physics and theories of literature are brought together, it is important to make clear the project's interdisciplinary position. The research field of literature and science has featured two major discussions in the last century: the Snow versus Leavis or 'Two Cultures' debate in the 1950s and 60s, and the 'Science Wars' or 'Sokal affair' in the 1990s. The first of these

was initiated by scientist and novelist C.P. Snow (1959/1998) with his lecture on 'The Two Cultures', in which he castigated humanists for being so ignorant of basic scientific principles as to make real communication between them and the scientists practically impossible. The resulting discussion over what kind of knowledge science and literature produce was famously continued by Thomas Kuhn's (1962/1970) theory of paradigm shifts and by the sociology of science as practiced, for example, by Bruno Latour (1987). Most recently the debate gained high visibility when physicist Alan Sokal offered to the journal *Social Text* an article entitled 'Transgressing the Boundaries: Towards a Transformative Hermeneutics of Quantum Gravity' (Sokal 1996a), which immediately after its publication Sokal revealed to be a parody of postmodern abuse of scientific concepts (Sokal 1996b). In the discussion that followed the scientists argued that poststructuralist conceptual analysis rudely misconstrued the true meaning of their ideas, whereas literary and cultural theorists were baffled by the scientists' inability to understand metaphor, irony and the value of the new meanings generated by the recontextualisation of scientific concepts (see e.g. Sokal and Bricmont 1998, Cordle 1999, Labinger and Collins 2001, Ashman and Baringer 2001).[13]

What, then, can be done to avoid the problems caused by such interdisciplinary incomprehension? Much depends on how interdisciplinarity itself is defined, whether it is seen as openness and innovation or as power struggle and appropriation. So far, perhaps the best-known analysis of interdisciplinary scholarship is Julie Thompson Klein's *Interdisciplinarity: History, Theory and Practice* (1990), in which the definitions of *multidisciplinarity*, *interdisciplinarity* and *transdisciplinarity* depend on the levels of the interaction taking place between disciplines. In this scheme (Klein 1990: 55-73), multidisciplinary approaches consist in the coming together of scholars from various fields to provide multiple points of view to a particular object or problem. Multidisciplinary approaches leave the methodologies of the individual disciplines more or less intact,

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[13] For an overview of these debates and the philosophical issues involved see Norris (2007: 107-133).

whereas truly interdisciplinary work, as Klein proposes, would involve some kind of methodological synthesis between the participating fields of research. Beyond these two co-operative modes Klein sets transdisciplinarity, with its aim for an overarching synthesis, or a larger vision covering several disciplines. Thus true interdisciplinarity, as Klein sees it, is defined not so much through the object of study – for example, a literary analysis of scientific texts – but through an adoption of methods from one discipline into another.

As Gillian Beer (1996) and Joe Moran (2002) have both pointed out, an interdisciplinary synthesis also implies a transgression of the accepted disciplinary boundaries and a questioning of the status of the various disciplines and the knowledge they produce. In *Open Fields: Science in Cultural Encounter* (1996: 173-195) Beer examines the way ideas transform when they move from one field to another, concentrating particularly on the adoption of scientific concepts into works of literature. Such a process, she argues, can never be limited to a direct translation of ideas from one realm to another, but always involves transformations and destabilisations. Similarly, Moran (2002: 15) describes literary interdisciplinarity as being fuelled by a postmodern questioning of the epistemological foundations of disciplinary boundaries. Disciplines, Moran (2002: 83-84) suggests, are a 'form of common sense, allowing us to keep doing what we do without continually speculating about its purpose, limits and ultimate worth'. What transgressive interdisciplinarity does is to question that common sense, and thus it should be viewed as 'a way of living with the disciplines more critically and self-consciously, recognizing that their most basic assumptions can always be challenged or reinvigorated by new ways of thinking from elsewhere' (Moran 2002: 187).

The transgression that can be seen as the defining element of interdisciplinarity in literary theory can turn in on itself and become transdisciplinarity: an imperialistic attempt at creating a Grand Unified Theory of human thought. The ferociousness of the recent Science Wars, for example, can be seen to have arisen

not so much from disciplines arguing over the suitability of particular uses of terminology (even though this is the format some of the most famous volleys, particularly by Sokal and Bricmont in 1998, have taken). Rather, the aggression arises from one discipline attempting to present itself as an overarching transdiscipline to another field or method of research, subsuming it either as an object of study (for example, when literary theory treats science as a cultural/textual phenomenon) or as a particular sub-category of itself (as when the natural sciences argue that literary study should be just another form of empirical research). Works such as Jean-François Lyotard's *The Postmodern Condition* (1984) and Gross and Levitt's *Higher Superstition* (1994) have exerted enormous influence in cementing the prejudices each field of research has harboured towards the other, the former by presenting scientific knowledge as a form of discourse and analysing it as such, the latter by virulently criticising sociological and cultural theories for not adhering to what the authors see as the rules of proper scientific research.

Judging from the theoretical discussion, it would seem that two prime motivations for interdisciplinary research in literature are transgression and epistemological questioning on the one hand, and attempts to achieve an overarching transdisciplinary status on the other. In their provocatively titled book *Academic Tribes and Territories* Tony Becher and Paul R. Trowler (2001: 59) explicitly describe many of the arguments arising in disciplinary margins as territorial disputes, and even a cursory look at the rhetoric of the Science Wars shows that in interdisciplinary discussion the implicit combination of the metaphors of ARGUMENT IS WAR and KNOWLEDGE IS TERRITORY has become a cliché. But often it is not quite clear whether the troops of one discipline are transgressing and aim to destabilise borders in a particular region, or whether they form the spearhead of an imperialistic invasion of transdisciplinarians.

This study does not aim to be interdisciplinary in the sense of applying chaos theory to literary works or to their interpretation. What it does, instead, is trace a cluster of concepts in literary works and in literary theory in order to find out how and why

those concepts are being used. In this it may drift from the traditional path of literary analysis and lean towards conceptual analysis or the history of ideas, but it certainly cannot be said to represent an in-depth methodological interchange between literature and mathematics or physics. However, I do engage the results of the sciences and, in particular, the way those results and their implications to human existence have been interpreted. Therefore I mean for Bohr's comment in the epigraph to this introduction to also be interpreted as an expression of the notion that science and literature reach profound truths each in its own way, without invalidating the other's discoveries. Elinor S. Shaffer (1998: 12) argues that '[t]he approach of the humanities to the sciences is in our time not just a curiosity or a diversion, or a parasitic colonization, or a rearguard sniping operation – though at times it has shown features of all of these – but a central feature of intellectual life'. Similarly, I believe that the reason for the relevance of the humanities to the sciences lies in the necessity of evaluating the results of scientific advances in terms of not only their ability to generate more science or better commodities, but also in terms of their consequences for our ideas about who, how, and where we are as embodied, conscious and imaginative beings. Chaos theory has been presented to the general public and to non-specialist academics as a paradigm that changes, for example, our view of the basic rules of interaction in the universe. In this study I analyse the ways in which literary authors and scholars have taken that message on board, and the questions they feel the new paradigm might be able to answer. These include the nature of the literary work as a structured object and how it can be described, the formation of an identity in the relationship between self and other, and, finally, the questions of mimesis, realism and epistemology. All of the underlying motivations for such interpretations reflect different conceptions as to what a theory of physics has to do with literary analysis.

Metaphorical and Non-Metaphorical Uses of Chaos Theory

The ways in which chaos theory has been adopted within literary studies vary considerably depending on the kind of contact they posit to exist between the science, the scholarship and the literary works under analysis.

At one extreme are the literary scholars who take as their starting-point the idea of historical and cultural contextualisation. Chaos theory has certainly inspired many authors of fiction, drama and poetry, and the most straightforward argument would be that a familiarity with the relevant scientific ideas is useful background knowledge for any scholar working with such texts. Slethaug's *Beautiful Chaos* (2000) lacks both the extensive claims and the revolutionary tone adopted by critics whose aim is to equate literature with chaotic systems. Slethaug's underlying assumption is that literary works reflect the understanding of reality current within their culture of origin, and since new scientific theories change that understanding, being aware of the science can help us in the analysis of individual works of literature. 'American literature within the twentieth century', he argues, 'had begun to change radically as conceptions of reality changed on the basis of technology and science' (Slethaug 2000: 5). Thus his own methods of literary analysis are not affected by the methodology of chaos as such, and the actual analysis of literary works is still conducted on the basis of contextualised close reading for themes, tropes and structures. Slethaug simply relates the conceptual make-up of the text, reconstructed on the basis of the textual elements, to the one presented by chaos theory. The only question mark raised by such scholarship in this context would be that it is not really interdisciplinary in the sense defined by Klein (1990).

However, there are also literary scholars who have explicitly stated that the application of chaos theory in literary studies is based on a true correspondence between the systems being studied. One example of such thinking can be found in Peter Stoicheff's essay 'The Chaos of Metafiction' (1991). Metafiction, Stoi-

cheff argues, is a dynamical system which happens to exist not in physical reality, but in language and culture.

> It seems, at first, curious that metafictional texts possess characteristics of chaotic systems in the phenomenal world, but they do. [...] As much as possible, I want to avoid using chaotic structures merely as a convenient metaphor or allegory for the structures contained within metafiction. [...] The crucial purpose in exposing the chaos and complexity of metafiction is not to provide another vocabulary through which to speak of a text; nor is it to suggest that the dynamics of metafiction are *like* those of chaos or of complex systems. Instead, it is to show that metafiction displays the properties located in what science calls chaos, and that a metafiction text *is* a complex system. (1991: 85)

The snowballing rhetoric displayed by this passage leads the reader through a series of steps towards the idea that literary texts can be equated with a physical system. Stoicheff begins with an equivocal suggestion of similarities and, as if gathering courage while writing the paragraph, ends with an unequivocal statement that 'a metafiction text *is* a complex system'.[14] After making his radical claim, however, Stoicheff does not apply the mathematical methods of chaos theory to the analysis of metafictional texts, but merely points – through expressions such as the 'Lorenz-like infinite tracings of interpretation', 'the chaos of indeterminate meaning' and 'the metafictional "narrative of chaos"' (Stoicheff 1991: 90, 92, 95) – at similarities between the assumptions concerning reality displayed in metafictional texts and in Prigogine's explication of chaos theory in *Order out of Chaos*. Considering the complexity of the literary text as an object of research, it is difficult to envisage the actual application of the detailed mathematical methods of chaos theory to literary works to be anything but a practical impossibility,[15] and many literary scholars would find such an at-

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[14] Another example of non-metaphorical presentation is Thomas Jackson Rice (1994: 46), for whom literature is 'a precise analog' of complexity in nature.

[15] Empirical studies of larger trends in literary history do, however exist. Martindale (1991), for example, presents equations to describe the appearance of word types in English poetry and suggests that the dynamics of

tempt to be nothing but yet another encroachment of the natural sciences into fields to which they are not suited.

The middle ground between these two positions is occupied by those literary scholars who use the concepts and terminology of chaos theory metaphorically. In some cases this is done in order to clarify or provide support for established practices of literary analysis, as is the case with Joseph M. Conte's *Design and Debris* (2002). Conte's aim is to make the interplay of order and disorder in postmodern American fiction more transparent by adopting the vocabulary of chaos theory in his formal analysis of literary works. Yet other scholars use the metaphorical connections between literature and chaos as the means of directing literary analysis towards new avenues for research. On the one hand, Michael Patrick Gillespie suggests in *The Aesthetics of Chaos* (2003) that literary scholars should learn from chaos theory to better accommodate ambiguity and inconsistency in their readings. On the other hand, William Paulson's (1991, 2001a) solution is to develop a chaos-inspired way of approaching literary texts that would respect their otherness, yet make analysis possible.

The objections to the adoption of chaos theory within literary studies also vary according to which of these correspondence levels are referred to. One common protest is that chaos theory serves no other purpose than that of providing scholars with impressive-sounding new terminology to bandy about (e.g. Matheson and Kirchoff 1997). Considering the field as a whole, a lot of the work being done in chaos theory and literature is certainly guilty of trying to offer old wine in new bottles. The motivation for such research is perhaps caused by the continuous pressure to find new and exciting approaches to literature, as well as by an ingrained feeling that the hard sciences can lend an air of respectability to research in the humanities. Patricia Waugh (1999: 43) has pointed out how even Lyotard in *The Postmodern Condition* uses 'the borrowed authority of science' to legitimise aesthetic know-

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those appearances is chaotic. For a discussion of quantitative and qualitative analyses in relation to chaos and literature see Bruce (1994: 152-157).

edge, even while he exposes the ways in which scientific knowledge justifies itself through relying on narrative means. Similar forms of argument can be found in many works on chaos theory and literature that refer to the natural sciences in order to gain support for a particular theory of literature; or as Joseph Flanagan (2003) has put it, eschew interdisciplinary 'collaboration' for 'corroboration'.[16]

If excessive deference towards the hard sciences is one source of criticism concerning chaos theory and literature, a converse problem arises when the interdisciplinary other receives too little respect. This occurs when connotations created within literary and cultural studies are reattached to the scientific context, as is the case, for example, with what chaos theory should, in fact, be studying. Having adopted the foci of chaos theory, some literary scholars have gone so far as to connect the technical meaning of the term 'chaos' to its older cultural meanings and then imply that the conceptual structure thus formed is (or should be) the object of study in both cultural and scientific research (e.g. Demastes 1998: 8-9). The difficulty in keeping such implications of transdisciplinarity out of cultural studies of science while still producing interesting conceptual analysis is, I believe, one of the major hurdles on the road to fruitful interdisciplinary research. Sometimes critics also allow the technical and cultural meanings to slide uncontrollably within their texts. For example, in Jude V. Nixon's discussion of the roles of energy and entropy in Gerard Manley Hopkins's poetry, the meaning of 'chaos' varies from being a synonym for entropy (Nixon, 2002: 139), to the existential horror which is the opposite of life and God (141), and to the naturally ordered beauty portrayed in Gleick's popularisation (139). Occasionally, such fluctuations can engender new meanings, but most often the result is merely confusion.

A further problem affecting many critics is that they imply a deep connection between scientific discoveries and literary phenomena without actually stating what that connection would be (or even making a speculation). In an article published in 2003

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[16] Knoespel (1991: 101-102) levels similar criticism towards Hayles.

Slethaug, who in his 2000 volume refrains from making interdisciplinary assumptions, implies that the connection between literary works and chaos theory has been established and needs no further argumentation. He compares the plot structures and symbols of Sherman Alexie's stories to chaos theory with the single explicit justification that both involve weather: 'A way of accounting for the relationship of order and disorder, chaos theory is often best seen at work in weather phenomena, and both the short story collection and film begin with an emphasis on weather' (Slethaug 2003: 132). In such cases I would agree with Stephen H. Kellert (1996: 215-216), who points out that 'the search for a bold new synthesis' between the sciences and the humanities does not require that we let pass 'causally flexible use of language or suggestive but tenuous leaps of reasoning'.

Considering the epistemological destabilisations associated with interdisciplinarity, it is perhaps not surprising that there is also a tendency among scholars to conflate literature as an art form with the study of literature as an academic discipline. Many (e.g. Beer 1996 and Porush 1991) call their own project interdisciplinary, but then explicitly confine their comments to the interfaces between literary works and the methodology of the natural sciences (how the ways that science and literature portray the world resemble or differ from one another); others (e.g. Paulson 1991) consciously use the term 'literature' to mean the artistic phenomenon and its study interchangeably. Such a blurring of the borderline between a field of study and its object is, of course, widely accepted within poststructuralist approaches in the humanities, but in the case of literature and science it tends to create problems when done unconsciously. It is also rare for scholars to make a difference between literary studies as a critical methodology and as theoretical study concerning the ontology of literary works – another issue where clear demarcations are notoriously difficult to draw, but which it is nevertheless important to be aware of when making interdisciplinary crossings.[17] In research

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[17] Cordle (1999: 31) has also noted that in the Two Cultures model literary criticism is either absent or conflated with literature.

into literature and chaos theory literature is often seen as a single system of discourse in which ontologies, methodologies, subjects and objects are constantly in flux but which is, despite this complexity, unproblematically compared with both the methodology of chaos theory and the dynamical systems it studies.

A useful list of further common accusations levelled against literary criticism engaging chaos theory has been complied by Cordle (1999: 67):

> the reliance on journalistic and popular accounts instead of actual scientific texts; a misapprehension of the importance of chaos theory to contemporary science and a consequent tendency to see it as a revolutionary development that has transformed science as a whole; and the use of terms with a specific technical meaning ('chaos', 'nonlinear', and so on) as though they are equivalent to their popular meanings.

Cordle himself points out that these objections do not, as such, apply to research which is conducted within the confines of the humanities and which aims only at tracing the movement of certain ideas through culture. Thus for most literary scholars, utilising chaos theory does not mean applying it to literature, but rather attempting to see how that thought complex fits (or doesn't fit) into the theoretical issues discussed in literary studies. Kellert (1996), for example, analyses theoretical texts that compare chaos theory with deconstruction and comes to the conclusion that the use of the quantitative techniques of chaos theory in literary studies is not possible. However, he does see a possible avenue which he calls 'metaphorical extension': '[T]he use of nonlinear dynamics as a new conceptual resource for other disciplines' (Kellert 1996: 216). Chaos theory might thus offer a world-view that, instead of being a scientific justification for something we already know about literature and culture, actually shows human beings, their art, their thinking and their relation to the universe in a new light.

While I also would like to underline the fact that the appearance of chaos theory in culture makes it available as an object of study for the humanities, it is also important to be honest about what I can and cannot say about it. I will not be attempting to

draw inferences back from literary meanings of chaos theory to what the science might be or should be about, and I will try to be very careful about being clear when the terminology is used in its technical sense and when with further cultural meanings attached. These and other issues of interdisciplinary terminology will be discussed more fully in chapter 1.

A final point to be made also concerns the limitations of this study. The multiplicity of uses to which chaos theory has been put makes it practically impossible to engage very closely with all of the relevant theoretical questions. A single dissertation attempting to discuss themes such as the ontology and structure of literary works, the formation of human identity and the relationship between literature and reality may already be overextending itself. As a result, many of the theoretical issues to which scholars refer receive only cursory but hopefully clarifying analysis.

Structure of the Study

My argument is structured around four theoretical questions that the literary interpretations of chaos theory can be seen to focus on: What is literary scholarship and how does it differ from the natural sciences? What is the nature of the literary work and how can it be analysed? What is the relationship between self and other, both in terms of human identity and the different agencies involved in the reading of a literary work? How does the human mind connect to the material universe and how can that universe be represented in literature?

Before engaging the literary texts themselves, it is necessary to clarify certain issues concerning interdisciplinarity and the movement of concepts and vocabularies between different disciplines. Thus chapter 2 discusses the ways in which the boundaries between the arts and the sciences have (or have not) been crossed by literary scholars' interpretations of chaos theory, and the ways in which chaos theory functions as a useful lens through which we can see the sometimes contradictory effects of research aims and the rhetoric used to present those aims. The critics and theorists

are seen to occupy a multitude of positions depending on whether they understand 'science' as an activity, as text, or as a body of knowledge.

Chapter 2 discusses the ways in which the concept of the strange attractor can be used in the discussion concerning the ontology of the literary work. While many theorists discussing chaos theory have taken fractal dimensions to be a way of pointing out the gaps in the seeming unity of a literary work, others emphasise the way concepts deriving from chaos theory can also describe the literary work as a definable shape, even though the exact relationships between its details could never be pinned down. Some critics and authors have also used the strange attractor as a metaphor for visualising narrative in terms of spatial rather than temporal structures. Tom Stoppard's *Arcadia*, for example, is consciously constructed on the seemingly contradictory ideas of fractal diffusion and the discernible shape of the strange attractor. On the one hand, the scenes of the play switch back and forth between the past and the present at an increasing rate, simulating the rhythm of period doublings with which the phases of a chaotic system bifurcate. However, the play ends with a scene where the two time periods come together in the form of two couples from different centuries waltzing to the same music, emphasising the harmony of the overall shape over the discordance of the details. John Barth's works also reflect a similar emphasis on structure over random details. In *On With the Story* Barth uses chaotic iteration as a structural tool which, instead of fracturing the narrative, enables the author to formulate both a narrative practice that allows for infinite variations within a finite narrative frame and the theoretical position of 'chaotic-arabesque postmodernism', also expressed in his essays.

Chapter 3 discusses the mind in communication with itself and with others, and the power relationships involved in such processes. The concept of individual identity is viewed in the context of emergent complexity, which helps to envision it as a dy-

namic but nevertheless recognisably unitary phenomenon.[18] Of the literary authors, John Barth, in particular, constructs an authorial persona through multiple iterations of themes, tropes and characters, and finally consciously utilises the symbolic structure he detects in chaos theory to describe the process. Other authors have found in chaos a metaphor through which to define the relationship between individual and community, nature and humanity, or even humanity and the divine. Mostly chaos theory is seen as a metaphor that helps the authors balance the needs and freedom of an individual with the larger pattern of universal laws.

Many authors present chaos theory as something which can connect human thought to the world by revealing the similarities in the structure and function of various systems, whether material or cognitive. In the works of Tom Stoppard and Jorie Graham chaos theory points towards an intuitive connection between mind and world, and between past events and present ideas. Chapter 4 takes part in the discussion concerning the representation of reality and suggests that even though these authors use many techniques associated with postmodern literature in general and metafiction in particular, their texts nevertheless reveal an evident mimetic intent. A central distinction made in this chapter is that departure from the conventions of literary realism does not necessarily imply a loss of interest in reality. As Susan Strehle (1992: x) has noted in her study of the literary adaptations of quantum mechanics, '[w]hile many living writers share a well-read fascination with the possibilities inherent in literary form, and while they make allied formal choices to replace realism, they do so in order to think more clearly about what we now understand as real'. Graham and Stoppard write the desire for both truth and art back into postmodern literature. They do not return to a naive form of realism but seek a dynamic interplay in which the possi-

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[18] A final note on vocabulary: I prefer not to use the technical term 'dynamical' in connection with the non-technical extensions discussed in this dissertation. Thus, while it has not yet been established that identity is a dynamical system in the sense meant by chaos theory, it can legitimately be described as 'dynamic' as opposed to static.

bility of truth is always present, even though it is also frequently questioned. Strehle (1992: 1-5) calls such works 'actualist', a term closely related to the 'externalist realism' I adopt in this study. However, Strehle's focus on quantum mechanics and poststructuralist theory gives her term a more epistemologically pessimistic tilt.

My conclusions present the humanist perspective in comparison and contrast with nineteenth-century romanticism and make some tentative suggestions as to the directions of future research. Those suggestions include the claim that, as the concepts of nonlinear dynamics seep more permanently into contemporary culture, the presence of chaos theory in literary studies is diffusing in such a way that the explicit reference to the concepts and vocabulary is supplanted by discussion which may well have benefited from those concepts, but which continues to employ the terminology of literary studies. By this I do not mean to say that the interdisciplinary field between literature and science is being abandoned by either party, only that activity may be shifting elsewhere along the border, perhaps even changing from forms of open conflict to mutual respect and diplomacy. One of the points about the approach delineated here is that rather than viewing the sciences and the humanities as either opposing or enclosing forces it attempts to combine a respect for the knowledge produced by the natural sciences with an equal respect for the expertise of the humanities in evaluating the cultural value and consequences of that knowledge. These are the interdisciplinary relations to which I will turn in my first chapter.

1.   *The Proliferation of Scientific Metaphors*

> Few things have played a more fatal part in the history of human thought and action than great imaginative analogies from one sphere, in which a particular principle is applicable and valid, to other provinces, where its effect may be exciting and transforming, but where its consequences may be fallacious in theory and ruinous in practice.
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> Isaiah Berlin, *The Crooked Timber of Humanity*[19]

> Interdisciplinary work crosses over between fields: it transgresses. It thus brings into question the methods and materials of differing intellectual practices and may uncover problems *disguised* by the scope of established disciplines. Forms of knowledge do not readily merge; they may lie askance or cross-grained. But that does not imply failure. Disanalogy can prove to be a powerful heuristic tool [...].
>
> Gillian Beer, *Open Fields: Science in Cultural Encounter*

> A good analogy is like a diagonal frog.
>
> Kai Krause, www.edge.org

As is suggested by the above quotations, there are wide divergences in opinion as to the validity and usefulness of taking a set of concepts and/or methods from one discipline and applying them to another. The authors disagree on whether such projects, in their transgression of disciplinary borders, reveal perspectives and problems to which previous methodologies have been blind, or whether they are exciting but finally meaningless speculations. Where Isaiah Berlin warns us against assuming that what is reasonable in one field of life and thought is also reasonable in an-

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[19] This quotation was first used in connection with chaos theory and literature by Willie van Peer (1998: 48).

other, Gillian Beer sees those same analogies as a 'powerful heuristic tool' which helps us overthrow ingrained patterns of thinking and thus promotes innovation. Kai Krause, on the other hand, manages to create a beautifully enigmatic analogy: a stylistically evocative statement (diagonal frog is almost an anagram of good analogy) which at the same time states that such evocativeness has no real meaning.

Before moving on to discuss the specifically humanist uses to which chaos theory has been put in works of literature, it is important to take a step back and have a look at the phenomenon of literature and science more generally. In the Introduction I briefly discussed the movement of ideas between science and literature and the ways in which that interaction has been conceptualised. This chapter will examine the more specific question of chaos theory and literary interdisciplinarity. The central issue turns out to be metaphor: what is the function and value of metaphorical connections between literature and the science of chaos?

In the following pages I try to answer this question by focusing on three different conceptualisations of 'science': as an *activity*, as *text* produced by that activity, and as *knowledge* produced by that activity and disseminated by texts. When viewed in the light of these three categories, the contributions to the study of literature and chaos theory can be seen to be responding to several different questions, rather than forming a unified research project. When science is understood as a human activity that exists within a particular cultural context, the literary appropriations of chaos theory concentrate on viewing chaos theory, too, as a cultural product, and treat both the mathematics and its artistic interpretations as equal expressions of a wider cultural field. From this point of view, a central question is who has the right to confine or metaphorically extend the meanings of the terms associated with chaos theory. If, on the other hand, the focus of research is on science writing, chaos theory is seen more as a source text, as part of the historical and ideational context of a particular literary work. From this perspective metaphor appears mostly as an evocative way to transmit the concepts of chaos theory to a lay audience,

and to form artistic expressions of its central concepts. Quite another aspect of taking chaos theory as text is full-scale textuality, which dissolves the role of acting agents and focuses on the relation of literature to science through the concepts of postmodern intertextuality. Finally, if literary scholars take science to mean the knowledge produced by scientific activity and transmitted by scientific texts, they tend to engage with chaos theory in order to change the way knowledge is defined and perceived, both within literary studies and beyond. This approach involves the most complex aspects of metaphor and consequently raises the most interesting questions. Does a metaphor say something no other means of communication can? Is a cross-disciplinary metaphor more than a clarifying image or a pleasing figure? Can a metaphor actually produce knowledge?

In recent research in science and technology, metaphor has received increasing attention. 'If scientists see mathematics and method as the two Ms that form the basis of scientific assaying', suggests Ken Baake (2003: 208), 'language scholars can rightfully add a third M – metaphor'. In his own analysis of the uses of metaphor in the scientific activity of the Santa Fe Institute in New Mexico, Baake (2003: 6) finds that metaphor is used widely and for a variety of purposes. These include both theory-constitutive and expressive uses: metaphor helps both in the early, conceptual phase when new theories are being generated (especially in an interdisciplinary context) and in the write-up phase when a particular project is presented to an audience as 'exciting, cutting edge and worthy of publication and funding'. However, in situations where the scientists 'want to appear rigorous and far removed from the social fray that discursive language inspires' they become wary of metaphor and try to limit themselves to technical language (Baake 2003: 6). This ambivalence is a reasonable response to a situation in which the different aspects of science as activity, text and knowledge interact. The value of heuristic metaphors for the creation of new concepts and that of evocative metaphors for the communication of those concepts to a non-expert audience is undeniable. But the point at which a scientist would want to step

back from metaphor is when he or she no longer feels that its connotations are either controllable or suitable to the constellation of scientific knowledge.

That suitability is defined through the general 'fit' of the knowledge imparted by the metaphor to all the other aspects of what is known. Baake (2003: 9) presents an analogy from music theory and suggests that the new meanings generated by a scientific metaphor must harmonise with the context in which it appears. Metaphors, he suggests, 'tend to be accepted if they sound sonorous amid the overall paradigm in which those scientists operate. So a metaphor and all of its meanings must fit into the theory in the same way a note and all of its harmonics must fit into a melodic phrase'. It is clear that many aspects of chaos theory have resonated strongly with literary studies. However, problems have arisen when literary scholars and cultural theorists have added to the metaphorical complex of chaos theory resonances which clash with other aspects of the physical sciences, as has been the case with some aspects of the poststructuralist interpretations of chaos.

Matheson and Kirchoff (1997), who have studied chaos theory metaphors in works of literary criticism, take the position that to employ the vocabulary of chaos theory as a metaphor in literary studies is inherently unprofitable. None of the texts creating metaphorical connections between literature and chaos, they argue, produces a truly novel reading of a particular piece of literature, and those claiming to produce connections that are more than metaphorical are only able to point to vague likenesses. In these interpretations, 'crucial terms such as "anticipates", "recalls", and "remarkably similar" are difficult to take seriously, since the words are presumably intended to connote more than slight and coincidental similarities between vague and general concepts – and as always, even these minimal similarities seem nonessential to the analysis that finally emerges', Matheson and Kirchoff (1997: 41) propose. They also offer a taxonomy of four ways of constructing analogies between objects, and argue that

none of them is of value as a methodology for chaos and literature studies.

> (i) B [chaos] allows us to learn about A [literature] in ways that could not be accomplished without modeling A as B. [...]
>
> (ii) Those unacquainted with A but knowledgeable about B can best learn about A by pursuing A's analogy with B. [...]
>
> (iii) Those who are somewhat acquainted with A can learn *more* about A by coming to learn about B.
>
> (iv) B is structurally similar to A, and this is inherently interesting. (Matheson and Kirchoff 1997: 41)

The first option is out, Matheson and Kirchoff (1997: 42) argue, because the interpretations built with the help of chaos theory could have been arrived at without it; the second does not apply, since the interpretations are written for other literary scholars and not for scientists; and the third is a problem, since the use of chaos theory does not, in their opinion, open up the text to readers not already familiar with chaos theory (at least not without a cumbersome explanation of the terminology used). What is left is the fourth option, which Matheson and Kirchoff argue not to be true in the case of chaos and literature, but which many others do find a valid point (see chapter 2).

This chapter will discuss the process of metaphorically transferring (both metaphorical and non-metaphorical) concepts and vocabulary from one discipline to another. What does it mean for a literary critic to say they are treating chaos as a metaphor for literature? Is Leo Steinberg (1986: 1) correct when he claims that being able to imagine 'ways in which some art, or some function of art, can be said, metaphorically, to be like some science' is inherently pointless, or, as Steinberg ironically suggests, about as interesting and relevant as comparing art and mountaineering? By way of an answer, I will examine the writings of a handful of literary scholars engaging chaos theory in order to show that the comparison between the two phenomena of chaos theory and literature brings to focus important issues of literary ontology and epistemology.

Hayles (1991b: 30) has suggested that there are several assumptions affecting critics responses to the question of whether chaos terminology should be brought into literary studies as metaphors or because of a direct correlation between the systems. A scholar wishing to answer that question, Hayles argues, would have to make clear what she believes the route of influence between science and literature to be, whether she thinks that language constitutes ideas or conveys them, and whether scientific inquiry is free from social and cultural influence. Although most scholars do not fulfil Hayles's request to discuss these issues explicitly, it is possible to bring out these unstated assumptions by analysing what exactly they mean by 'science', and, in turn, examine those assumptions in order to get to grips with the dynamics of interdisciplinary knowledge.

1.1   Heuristic Metaphor: Science as Activity

> [O]ur interviewees have tended to agree that much of the power of descriptive words, including metaphoric words, lies in their flexibility to change connotations according to situation. These chameleon-like terms allow scientists to see new associations among seemingly disparate ideas [...]. Struggling to find rigorous definitions, however frustrating that process may be, is as much a part of science as is laboratory field work.
>
> Ken Baake, *Metaphor and Knowledge*

The history of scientific developments is littered with dramatic stories of moments of discovery. Some of them, like the famous anecdote of August Kekulé realising the structure of the benzene ring in a vision of a snake eating its own tail, describe the role a heuristic metaphor can play in the scientist's mind in guiding it towards the discovery. Once such metaphors have entered into scientific discussion, they engage the scientists in the work of sort-

ing out the various connotations produced and in finding out which ones have explanatory force. Sometimes these metaphors remain in the scientific parlance and spread into the minds of the general audience, where they may mutate enough to cause a backlash from the side of the scientists, as has happened in the case of chaos theory. Occasionally their presence even raises the question as to whether science is actually about discovery or about invention. Since so many problems have arisen from the prolific connotations of a word such as 'chaos', it is relevant to ask why scientists would choose such an evocative term in the first place. This reason, naturally, has much to do with the way metaphors play a part in scientific conceptualisation. It is also a question that leads me to those literary appropriations of chaos theory which see science mainly as a human activity, whether discovery or construction.

Philosopher Rom Harré (1986: 8) sees science primarily as an enterprise rather than as a collection of facts and theories. Science, he argues,

> is not a logically coherent body of knowledge [...], but a cluster of material and cognitive *practices*. [...] Science is an activity: it is something people *do*. Some, but not all of that doing is thinking, and a yet more minor part of it is producing discourses in which the results of making those material manipulations and doing that thinking are recorded.

Thus cultural study of science in this sense takes the form of sociological research into what scientists actually do. In literary studies the influence of sociological science studies, combined with poststructuralist theory, has created a conceptualisation of 'science' as one human activity among others, and, in particular, an activity which is enclosed within the system of culture.[20]

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[20] For a useful condensation of the discussion of representation in sociological studies of science see Knuuttila (2005: 21-36).

Sociology of Science

If poststructuralism caused many theorists to view literature as enclosed within a self-referential bubble, Kuhn's *The Structure of Scientific Revolutions* (1962/1970), was interpreted as proving that the settlement of scientific disputes does not proceed on the basis of how things actually are in nature, but depends, instead, on disciplinary paradigms that make it possible to think in a certain way and in no other. Even though Kuhn (as quoted in Harris 1996: 81) later tried to point out that paradigms *do* change, and as far as he is concerned, change to match reality better and better, the effect of culture and society on the questions that the scientific community chooses to ask has remained the most influential idea in the book. That view was taken up most notably by David Bloor's *Knowledge and Social Imagery* (1976) and the strong programme in the sociology of scientific knowledge. In literary studies, particularly in feminist and postcolonial studies, some scholars (e.g. Keller 1985, Haraway 1991 and Harding 2006) have consequently presented science as struggle for power that is based at least as much on cultural construction as on objective observation.

One consequence of the sociological study of science has been that it has emphasised the view, initially present in the popular books (e.g. Gleick's *Chaos*), that the 'new science' of chaos is an epistemologically revolutionary movement in science. The implication is that the initially marginalised institutional position of the chaos scientists would also mean that chaos theory itself was a marginalised and anti-establishment form of scientific inquiry. Demastes (1998: 8), for example, suggests that chaos theory is a instantiation within scientific practice of themes that affect culture more generally: 'The point is simple: our contemporary culture has become obsessed with issues of unpredictability and uncertainty at numerous levels – economic, social, political, spiritual'. Similarly, Slethaug (2000: xi) notes that the role of chaos as counter-culture is dependent on its interest in the turbulent mar-

gins of known and ordered behaviour, which aligns it with other, postmodern cultural theories:

> It is perhaps this insistence on marginalization that gives chaos theory at least some of its appeal for the modern writer and reader of recent American literature. [...] Although it further confirmed the importance of science in all our lives, this alternative mode suggested that dominant views of science – if not science itself – could be contradicted, that it was not, as some thought, monolithic, orthodox, single-minded, or at one with itself, and that, therefore, it was available to the sceptical humanist.

Slethaug and Demastes represent fairly moderate views of how chaos theory and postmodern uncertainty interact in a larger cultural framework. There are, however, other literary scholars for whom chaos represents a revolution within the epistemology of the natural sciences. Many of these views depend on arguments where the metaphor chosen by scientists for the behaviour of dynamical systems is extended to include meanings which are interesting and relevant within the context of cultural studies, but do not resonate with the scientific context. For example, Brian Ward (1998) notes that in *The Transparency of Evil* (1990) Jean Baudrillard uses chaos theory not as knowledge that science has gained about the function of the universe, but as part of a social and cultural constellation of values that directs the actions of scientists and cultural theorists alike. 'The concepts of chaos theory are upheld by theorists like Baudrillard as powerful tools which are able to validate cultural impressions of social systems as chaotically determined systems', Ward (1998: 243) suggests. He further argues that the basis for such uses of chaos is also accepted in the sciences. The purposes to which it is put in cultural studies, Ward (1998: 243) claims, matches the focus on instability and breakage in the natural science approaches: 'It is essential to recognise that this impression of the principles of chaos theory is not fundamentally inconsistent with the perception of their value within science'. Scientists have, however, expressly denied that chaos theory's principles would mean a revolution in the epistemology of the scientific process. I will return to this point in the following

section, but suffice it to say here that Ward seems to accept the sociological view of science as a cultural and social activity, which in turn validates the implication that the cultural meanings attached to the scientific metaphor are so strong that they should be taken into account within the scientific context as well.

It is clear that the strongest criticism towards using chaos theory in literary and cultural studies has come from scholars who are reacting against just such appropriations. Gross and Levitt (1994: 92), for example, take the chaos theory discussion to be a part of a larger attack by constructivist epistemology. Because of the emphasis chaos theory gives to margins and unpredictability, they suggest, it 'has been a proving ground for postmodernist critics eager to try their apparatus in the venue of modern scientific thought, and eager to justify their philosophic maxims by appeal to ostensible "paradigm shifts" in science'. However, interpretations based on the strongly constructivist position are actually quite rare, even though many literary scholars have allowed similar implications to slip into their rhetoric. For this reason some of the attacks against literature and chaos, Gross and Levitt's in particular, can come across as overkill and result only in obscuring the underlying reasons why literary scholars choose to engage chaos theory in their writings.

Similar questions arise when we consider ideology within science and literature studies. It is clear that sometimes literary scholars allow themselves to be swayed to promote a scientific theory – or a particular interpretation of the consequences of a theory – because they see it as matching a particular ideology. For example, Kellert (1996) criticises Gross and Levitt for turning a blind eye to Alexander J. Argyros's (1991) scientific mistakes and castigating Hayles for hers, despite the fact that Argyros makes use of far less tenable arguments than those employed by Hayles. The reason for the imbalance, Kellert believes, is that Gross and Levitt agree with Argyros's political aims. 'After all' Kellert (1996: 229) suggests,

> Hayles has claimed that a rough similarity between chaos theory and deconstruction shows that they both developed in response

to some common cultural constraints. Argyros, on the other hand, claims that chaos theory shows Derrida to be wrong, and that nonlinear dynamics provides an objective ground for enlightenment values, traditional narrative, and liberal democracy.

From Kellert's (1996: 230-231) perspective, 'no one group of people has a preemptive right to decide what chaos theory does or does not mean', but, rather, all the interpretations, including scientific ones, invest in the term their own cultural context. Advised by the arguments concerning the politics of chaos theory I suggest that exposing bias in scientific theory can, as Ann E. Cudd (2001: 96) argues, actually increase the objectivity of science as a process. Accepting the fallibility of individual researchers does not, however, need to invalidate the epistemological goals of the entire project of science. The point I hope to make here is that interdisciplinary research which takes as its starting point the view of science as an activity directed by cultural prejudices will lead to very different conclusions about the cultural meanings of chaos theory than if the starting point is a view of science as an activity which itself can direct culture towards new conceptions of reality.

Among the literary scholars who present science as an activity, the role of chaos theory tends to be to emphasise some form of constructivism. Stoicheff, for example, whose view of metafiction as a chaotic system was discussed in the Introduction, rests his argument on the assumption that the construction of meaning in metafiction is similar to the way chaos theorists construct knowledge. Thus the emphasis in his epistemology is on the interpretation, rather than observation, of the world: 'Metafiction and scientific chaos are embraced by a larger revolution in contemporary thought that examines the similar roles of narrative, and of investigative procedure, in our "reading" or knowledge of the world' (Stoicheff 1991: 85). The new transdisciplinary paradigm which results from that revolution will for Stoicheff be a methodology which questions the objectivity of our world-view and is mainly interested in the ways in which meaning is constructed.

A more nuanced text is Hayles's *Chaos Bound* (1990), in which she maps the relationship between chaos theory and postmodern literature and culture, centrally discussing works by Henry Adams, Stanislaw Lem and Doris Lessing. In her 1984 volume *The Cosmic Web*, Hayles had already outlined a model of cultural practice based on the idea of an interconnected field in which the strict separation of different disciplines is impossible, and in which science is one among many cultural activities. In *Chaos Bound* Hayles openly positions herself as a transdisciplinary commentator on literature and science as cultural phenomena which reflect a shared, underlying network of ideas and influences, a network which also happens to exhibit characteristics of chaos.

> Different disciplines are drawn to similar problems because the concerns underlying them are highly charged within a prevailing cultural context. Moreover, different disciplines base the theories they construct on similar presuppositions because these are the assumptions that guide the constitution of knowledge in a given episteme. This position implies, of course, that scientific theories and models are culturally conditioned, partaking of and rooted in assumptions that can be found at multiple sites throughout the culture. (Hayles 1990: xi) [21]

Despite applying the tools of literary and cultural studies to the natural sciences, Hayles does not, at least explicitly, attempt to claim that science as a methodology is ruled solely, or even mainly by cultural forces. It should also be noted that Hayles is not saying that chaos *mathematics* can be used to understand literary works, but that its development in the intellectual sphere sheds light on other similar developments in the field of literary theory. Against this background, her literary analyses concentrate on showing the presence of the paradigm of chaos in her chosen works, and rely on traditional methods of close reading and historical and cultural contextualisation. Hayles is, however, more aware of the ambiguities of her situation than many other scholars, and reminds the reader that if her field model of cultural influences is correct, her

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[21] Many scholars, for example Hawkins (1995) have explicitly adopted Hayles's scheme of the chaotic cultural field.

own position is embedded in the matrix she is analysing, and thus she cannot claim to present an objective 'view from nowhere'. 'At best,' she admits, 'I have reenacted the cultural dominant in such a way as to make its dynamics clearer than they may have been before' (Hayles 1990: 293-294). Thus Hayles weaves together a transdisciplinary view of a cultural dominant that affects all scientific activity, and a transgressive questioning of all the knowledge produced by disciplines under the influence of that cultural dominant. This questioning includes her own work, even though the implication remains that literary or cultural analysis is the 'metamethod' through which the dynamics of the cultural dominant are clarified.

Even Hayles, though, is not immune to the difficulties and confusions involving interdisciplinary chaos studies. One rare lapse into vague argumentation over the relationship between scientific and literary objects and discourses occurs in her preface to Braun and McCarthy's *Disrupted Patterns*. Here Hayles (2000: 2) suggests that 'metaphoric parallels between the science of chaos and literary texts allow critics to treat these texts as if they were chaotic systems'. The first problem in this seemingly simple sentence is the conflation of the 'science of chaos' with the 'literary texts'; of a methodology of one discipline with the object of another. In the second half of the sentence Hayles equates the texts with chaotic systems themselves, revealing an underlying (and perhaps intended) uncertainty as to what is actually being compared (however metaphorically) with what.

The Context of Discovery

By discussing science as an activity these critics and theorists concentrate on the context of scientific discovery. It is clear that scientists do use ideologically charged metaphors and that often their research activity and eventual discoveries are directed by the metaphors chosen to describe particular phenomena. As Baake's study (2003) shows, the contextual reasons as to why one metaphor is chosen instead of another can be cultural, and thus a le-

gitimate topic of research for a cultural scholar. However, whether this cultural influence on scientific metaphors justifies extending the field of reference of those metaphors once they move away from a purely scientific context is a more complex issue. In *Open Fields* Gillian Beer (1996) notes how often a new conceptualisation in the natural sciences is initially given an evocative name in order to help colleagues to fill out the blanks in the theory, as well as in order to signal to them that the theory is still without proper definition (Beer 1996: 184). Dependence on such heuristics, Beer (1996: 157-158) argues, has led to the practice of

> impressionistic or whimsical naming which is fashionable in high theory today: words such as 'charm', 'quark', or 'black hole' deliberately evade severe equivalence in order to allow space for correction and enhancement without the need constantly to replace and to move on from terms. [...] Language is a heuristic tool but it may best function at the frontiers of scientific knowledge by adopting a mode which sounds strangely belletristic.

It is clear that the open-endedness of scientific metaphors is a vital part of their heuristic function.[22] But how can such open-endedness be reconciled with the theories of reference and the precision required of a scientific theory? I will return to this question in the following sections, but perhaps it will suffice to point out here that, as Beer suggests, what makes the restricted and changing meanings of a scientific metaphor communicable are the resonances provided by the scientific context. Therefore, scientists reading each other's non-mathematical explanations concerning new concepts agree to restrict the possible meanings of the heuristic metaphor to the context of the particular scientific theory being discussed: 'Not what is said, but the agreement as to constraints on its reception, will stabilize scientific discourse' (Beer 1996: 159). Such agreements concerning the constraint of constructed meaning are often viewed in a negative light in cultural science studies, which considers them as exclusionary and

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[22] See also Ricoeur (1978: 20-22), Harries (1978-79: 87), Quine (1978-79: 161), Boyd (1980) and more recently Haack (2003: 225).

distorting. They are, however, a necessary part of the communicability of heuristic metaphors.

Similar phenomena can also be found in interdisciplinary literary studies, where the technical language of science (especially in its belletristic forms) is adopted as a way to approach new ideas. When new interdisciplinary conceptualisations are introduced, the argumentation may often overreach itself and produce work that seems to present untenable and unrealistic comparisons between disciplines. As Weingart and Maasen (1997: 496) have suggested, many early chaos-and-literature scholars seem to be merely adopting exciting vocabulary to describe mundane interpretations. Thus the use of cross-disciplinary metaphors, they suggest, does not necessarily indicate interdisciplinary activity, rather the opposite. '[E]ven those who are most engaged in this process [of combining chaos and literature]', they argue, 'discuss its pros and cons with their disciplinary colleagues rather than with chaos scholars from other disciplines'. The concepts of chaos theory are included, as it were, within the discourse of literature, and not treated as part of another field with which to engage in dialogue. This strategy, Weingart and Maasen argue, actually precludes the possibility for the 'major epistemic shifts' that interdisciplinary studies are so famous for (Weingart and Maasen 1997: 496). However, the strategy can also be seen in terms of literary scholars trying to restrict the resonances of the imprecise vocabulary they have adopted, in the same way as scientists have wished to corral terms like 'chaos'. The real contradiction happens if a literary scholar simultaneously attempts to restrict their use of terminology to the literary context and at the same time claim an extensive interdisciplinary status for their work.

If Weingart and Maasen argue that literary scholars do not take science seriously as an interdisciplinary partner, others have suggested that the use of scientific terminology in literary analysis arises from respecting it too much. Earlier in this chapter I noted how Matheson and Kirchoff strongly criticised literary scholars for equating chaos theory with literature. They also suggest that Hayles, among many others, is guilty of displaying a 'gee-whiz atti-

tude' which arises from a keenness to tell other literary scholars about the scientific discoveries, rather than engaging in a truly interdisciplinary dialogue with those sciences (Matheson and Kirchoff 1997: 31). However, Matheson and Kirchoff's stern position has itself been criticised as 'occasionally arrogant, sometimes categorical, and perhaps all too dismissive' (Braun and McCarthy 2000b: vi-vii). The fact that many of the attempts to assimilate the scientific analysis of chaotic behaviour to the study of literature are superficial and even severely flawed in their ontological starting points does not necessarily mean that the entire endeavour is without basis. It may merely mean that the rhetoric should be understood in the context of incipient interdisciplinarity where the visions of the project often extend beyond the authors' ability to formulate those visions in argumentative language.

How, then, should the cultural study of science be justified as an academic endeavour? One solution is offered by Cordle (1999: 51) who separates two specific aspects of science and labels them 'professional science' and 'cultural science'. The former refers to 'the set of practices and expertise that make up the life of the working scientist, and in order to participate in which he or she must be trained'. The latter, 'anything that contributes to the general perception – the cultural "value" – of science', is the valid territory of cultural studies in general, and when it comes to texts, of literary studies in particular. Such research, Cordle (1999: 61-72) argues, could consist of, for example, 1) tracing the influence of science in particular works of literature, 2) examining the representations of science and scientists, 3) rhetorical analysis of scientific, particularly popular science texts, 4) tracing the appearance of shared metaphors in the two discourses, or 5) the larger disciplinary questions of the 'Two Cultures Debate' as well as the similarities and differences between literary theory and the methodologies of the natural sciences. While the last question is reserved for the final section of this chapter, the following pages will examine the first four.

1.2   Rhetorical Metaphor: Science as Text

> In adapting natural languages to the construction of experimental science, the creators of scientific discourse developed powerful new forms of wording; and these have construed a reality of a particular kind – one that is fixed and determinate, in which objects predominate and processes serve merely to define and classify them. But the direction of physics in the twentieth century has been exactly the opposite: from absolute to relative, from object to process, from determinate to probabilistic, from stability to flow. [...] The language [the scientists] learned at their mothers' knees is much more in harmony with their deepest theoretical perceptions.
>
> M.A.K. Halliday and J.R. Martin,
> *Writing Science: Literary and Discursive Power*

Scientists are not just individual human beings engaging in an activity, they are also users of natural language. When notions of theoretical physics that in some sense properly exist only in the language of mathematics are translated into natural language they undergo a transformation into a context that is much more flexible. In such a context evocative metaphors are used not to aid the scientist, whose own conceptualisation is at that point ready and mostly fairly precise, but to aid the (often non-specialist) audience to whom the scientist is attempting to convey that conceptualisation. These metaphors naturally exist as part of the cultural context within which the explication appears. A classic example within the history of chaos theory is the birth of Edward Lorenz's butterfly.[23] Lorenz's original idea was to illustrate the turbulence

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[23] One of the earliest discoveries of chaotic behaviour. The meteorologist Lorenz was interested in finding regularities in a series of twelve calculations describing atmospheric conditions – wind direction, level of moisture, temperature, and so on. What his research showed was that in chaotic systems the assumption that causes have proportional effects is not a valid one, but instead one minute change sparks another and another, until the

of weather by saying that the flap of a seagull's wings might cause catastrophic changes to the weather on the other side of the world. His colleagues, however, drew his attention to Ray Bradbury's short story 'A Sound of Thunder' (1952), in which a time-traveller inadvertently kills a prehistoric butterfly and thus cancels the development of human civilisation in its entirety. Seeing the similarity between the sensitivity to initial conditions in both his weather calculations and in Bradbury's story, Lorenz decided to change the gull to a butterfly (Hawkins 1995: 2 and n. 2). It is clear, therefore, that the individual evocative images chosen to carry scientific theories are dictated by not only the requirements of the theory itself but also by the scientist's cultural context.

In the previous section I focused on the use of metaphor in the context of scientific creativity, and here I move on to discuss the forms of metaphorical usage waiting on the other side of the mathematical formulation: scientific writing and, in particular, popular science. Taking into account the kind of criticism aimed at the strong sociology of science, many literary scholars find that the rhetorical analysis of scientific texts is a much more natural approach to take, as well as being one which need not embroil them in the depths of philosophy of science. However, understanding 'science' as the texts produced by scientific activity can also be a way of encompassing the whole of science within the purview of literary theory and scholarship. As Halliday and Martin suggest in the above epigraph, a language entails a world-view, and through the analysis of language a literary scholar can also conduct analysis of the entire world-view implied by that language. In fact Halliday and Martin claim that contemporary physics is in itself more suited to being expressed through indeterminate discourse than in the more strictly determined forms of argument formulated in the previous centuries. In some ways this is true, but there is also a difference between, firstly, the claim that a world-view which is as conceptually complex as the one presented by contemporary physics is too odd to be explicated by the kind

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behaviour of the system may bear no resemblance whatsoever to the original predictions (Gleick 1987/1989: 9-18 and Stewart 1989/1997: 121-129).

of discourse scientists usually adopt when using natural language, and secondly, the more radical claim that that world-view would be too complex to be precisely expressed in mathematics.

Rhetorical Aspects of Scientific Texts

In *Rhetorical Figures in Science* Jeanne Fahnestock (1999) makes the point that the presence of metaphor in scientific texts has opened various avenues of research for the cultural study of science. Regarding metaphors as the root of scientific creativity, she suggests, could lead to a way of explaining the development of new knowledge while still preserving the romantic idea of individual creativity. But Fahnestock also notes that in some literary scholars and poststructuralist philosophers the discovery that scientists also use metaphors 'releases a unifying "cluster of pieties" about how scientists and poets are basically alike' (Fahnestock 1999: 5). Both of these notions (metaphor as a heuristic, and as a sign of the construction of scientific knowledge being fundamentally similar to any other construction) were discussed in the previous section. Fahnestock (1999: 5), however, also notes that the concreteness of scientific metaphors as textual elements increases their attractiveness as an object of study: that 'while metaphors are epistemological constructs, they are also identifiable, formal devices. Given an appropriate definition, they can be pointed out, providing evidence for the scholar working with texts'.[24] This section concentrates on the interdisciplinary status of those literary interpretations of chaos theory that focus on science as writing, with the particular aim of looking at the ways they treat scientific metaphors that appear in the texts published by scientists or popular science writers.

The rhetorical analysis of scientific texts is a relatively marginal field in literary studies, but it has received increasing atten-

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[24] Fahnestock (1999) also includes analysis of other rhetorical tropes in scientific writing, such as antithesis and antimetabole. For these and other rhetorical relations between popular science writing and contemporary literature see Aarnio (2008).

tion within, for example, sociolinguistics. The benefit of such analyses for interdisciplinary discussion lies in the possibility of making detailed mappings of an individual author's background assumptions, and in reading against the grain, which can be more revealing than an interpretation that stays within the author's designs. A good example of such an effect is Secor and Walsh's (2004) analysis of Alan Sokal's hoax article. Their detailed examination of the rhetoric of both Sokal's writing and the previous issues of the journal *Social Text* shows that Sokal probably succeeded in getting his article accepted not just because of the ideas presented in it, but because of the rhetoric used. Firstly, Sokal's text was a successful pastiche in the sense that it managed to replicate the conventions of the articles usually published in *Social Text* extremely well (Secor and Walsh 2004: 77-88). Because the editors had become too blind to their own conventions, Secor and Walsh (2004: 88-89) argue, they failed to see the oddness of Sokal's discourse, or, alternatively, they assumed that Sokal's overblown versions of the common rhetoric of cultural studies was caused by the author being an over-eager outsider attempting to fit in. 'Sokal's hoax, and all media hoaxes', Secor and Walsh (2004: 89) suggest, 'teach us that the very act of reading is an inescapably social and rhetorical event; it is a political statement, an affirmation of group membership, and a continual reconstruction of moral, ethical, and public reality'. A literary scholar approaching science as writing can therefore take rhetoric as their starting point and come to interesting conclusions as to the epistemological assumptions prevalent in the texts. From this perspective, metaphor is mostly seen as a rhetorical device among others, although a particularly effective one, especially when the reader is expected to formulate a new conception of the physical world.

It should be kept in mind that popular science writing as a genre differs from professional science writing in many respects, one of them being rhetorical.[25] Where professional science texts aim to impress their argument on an audience of peers who not

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[25] For an overview of the publication history of popular science writing in the early 20th century see Whitworth (2001: 26-57).

only require much less explanatory rhetoric, but are also expected to be interested in the subject matter without having to be particularly persuaded to do so, popular science writing must attract a lay audience, keep up their interest, and along the way explain complex new concepts and phenomena without technical vocabulary or (much) mathematics. This does not need to mean, however, that popular science texts should be taken as somehow less complex or less worthy examples of science writing. They simply have a different purpose and are (mostly) aimed at a different audience.

In an article on the rhetoric in and the dissemination of popular scientific books on chaos theory Deannette Paul (2004: 37-46) makes an important point concerning the increasingly varied audience that such texts have in a world of scientific specialisation. Paul argues that Gleick's *Chaos* in particular had an impact not only among the general public but also within the professional scientific community. Increasing specialisation has led to a situation where scientific experts in one field may find themselves just as ignorant as anyone else of the details and the import of a new theory, and will turn to popularisations to gain a general view of such a field. Such a situation, Paul suggests, arises particularly at the birth of new theories. As a theory is developed further the rhetoric of the popularisations changes to reflect the changing aims from the early example-oriented rhetoric to the semipopular stage aimed at other scientists and concentrating on staking claims, and finally to the stage where the text is actually aimed to inform and entertain a general audience.

In order to accommodate all these varieties of non-technical writing, a panel of contributors to the 1995 meeting of the Society for Literature and Science in Los Angeles suggested 'reflective science writing' as an alternative term to 'popular science'. The new term was defined as 'writing by scientists for nonspecialists in prose styles that reveal recognizable "literary" qualities, differing in this way from the writing of scientists for other scientists' (as quoted in Cordle 1999: 64, n24). The new term has the value of avoiding the stigma attached to the word 'popular', and although

it is fairly cumbersome and has not managed in general discussion to replace its predecessor, I shall adopt it in this context. I particularly wish to keep in mind the implications of the phrase: reflective science texts are often not only aesthetically pleasing reading, but also, while not *being* science (or at least all of science), they 're-flect' (on) the process and the knowledge produced.

The reflective nature of such writing carries with it certain risks, however. It is typical of such books (whether written by journalists or actual scientists) to make far-reaching philosophical or ethical claims that are based on the new world-view presented by the author. Michael H. Whitworth (2001: 50) has noted that this has much to do with the structure of narrative expected by readers, and that the story of the discovery has to end with suitably extensive pronouncements about the changes the new knowledge will bring:

> The book format demands and facilitates such conclusions. It demands them insofar as readers of books expect some form of closure, and it facilitates them, in that the structure of a book is less tight-knit than that of a short article; claims that would seem illogical or ludicrous in an article seem plausible at the end of a larger and more complex structure.

This is particularly true when a new field of science, like chaos theory, is attempting to establish itself. As titles such as *Making a New Science* (Gleick) and *Man's New Dialogue with Nature* (Prigogine and Stengers) suggest, chaos theory was initially presented, especially in reflective science writing, as something radically different in the sciences. Although its mathematical tools were not in themselves revolutionary, the combination of the mathematics, the possibilities offered by powerful computers, and the wide variety of systems to which the mathematics was being applied, made chaos theory seem something more than a regular step in the development of better mathematical models of physical systems. But, as I suggested in the previous section, to call its advent a paradigm shift to postmodern epistemology within natural science is going too far. Many scholars have argued that the revolutionary status of chaos theory in the sciences is little more than a mirage

created by the popularisations (see e.g. Knoespel 1991: 104-105, Matheson and Kirchoff 1997: 31).

The reasons for the mirage may, however, have their roots already in the professional science articles on chaos theory and on an overenthusiastic reading of those articles. Firstly, the conventions of scientific writing may themselves lead interpreters astray. When a new field of professional science is developing, its practitioners have a tendency to publish 'revolutionary' articles that differ from the normal scientific conventions used in presenting information and in attracting reader attention. In this chaos theory is no exception. Paul and Charney (1995), in their analysis of the rhetorical strategies of professional articles on chaos theory, found that where the established convention is to begin a scientific article by a review of previous work and then pointing to an area which has not yet been explored, the very early articles on chaos theory begin, instead, with a familiar example of a phenomenon that has not been adequately explained by the existing theories. This comes across not only as a more exciting starting point for a narrative, but it also allowed scientists 'to aim for a broad audience of general scientists rather than appealing to the narrow research concerns of a specialized field' (Paul and Charney 1995: 427). However, as soon as chaos theory developed as a field of research the earlier convention, along with other similar ones, settled back into place (Paul and Charney 1995: 404-405).

Secondly, reflective science writing has perhaps overemphasised the novelties of the theory. Gleick, for example, has been criticised for making his narrative of chaos theory's development into a story of anti-establishment frontiersmen (Hayles 1990: 145-146, Porush 1993: 156). While Gross and Levitt (1994: 94) find that Gleick's book is 'recommendably accurate on the underlying mathematical principles and their relevance for a host of scientific questions', they also argue that it,

> perhaps inevitably, overdramatizes the history of the subject in trying to make its protagonists fascinating. In point of fact, there is nothing, on the level of personal idiosyncrasy, that can be said to distinguish specialists in chaos theory from other mathemati-

cians and theoretical physicists. They are not pointedly more heretical in temperament. [...] Moreover, chaos theory, for all its beauty and scientific relevance, is *not* the dominant theme in contemporary mathematics, for the simple reason that nothing is.

Prigogine and Stengers, on the other hand, do not focus on the pioneers of chaos theory but on its philosophical, even transcendental implications. According to Gross and Levitt (1994: 96), despite his impressive career as a scientist, Prigogine has in *Order Out of Chaos* 'slipped into habits of speculation that involve him in very shaky science and even shakier mathematics', and even Hayles (1990: 91), who finds herself attracted to Prigogine and Stengers's 'vision', believes that the book ought to carry 'a warning label': 'CAUTION: Use at own risk. Authors have speculated beyond data. Conclusions are conjectural'.[26]

The point is that literary scholars who approach science as text to be analysed have an opportunity to bring to light certain rhetorical and even ideological characteristics of those texts that might otherwise escape notice. Through their rhetorical analysis Paul and Charney, for example, managed to show that some of the revolutionary flavour of the early chaos theory publications arises from the use of the argumentative conventions that are dependent on the traditions of professional science writing as a genre. As will be seen below, many literary researchers would have benefited from familiarising themselves with such conventions whereas, lacking that knowledge of context, they create readings of the implications of chaos theory that the scientists do not recognise as part of the same conceptual structure.

Among the general audience the very name of chaos theory conjures up associations that do not, in fact, have anything to do with the science itself. From Hayles (1990: 8-9) onwards, most literary scholars commenting on chaos theory have noted how the term 'chaos' has travelled in and out of the scientific context. Weingart and Maasen (1997), for example, discuss the way the word has acquired several different meanings at different periods

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[26] For more in-depth analysis of the status of Gleick's and Prigogine and Stengers's books see Porush (1993).

of time and in both scientific and general usage. Chaos as the opposite of cosmos, as lack of differentiation from which the cosmos is born, is a meaning originating in Hesiod's *Theogony* and was in use through Aristotle and the Stoics, St Augustine and Paracelsus. In the nineteenth century thermodynamics and entropy emphasised the more limited idea of chaos as the opposite of order, a sense which overwhelmed the parallel one in use by authors such as F.W.J. Schelling and Friedrich Nietzsche, and which saw chaos as the source of order. It is this latter sense which, Weingart and Maasen argue, was resurrected by the natural sciences when they spoke of 'chaos' theory (1997: 478-480).[27]

The first use of the term as descriptive of nonlinear dynamics is accredited to Li and Yorke for their 1975 paper 'Period Three Implies Chaos', and throughout the 1980s the word was widely used in scientific texts (Weingart and Maasen 1997: 469-470). Most scientists writing about chaos are of course aware of the multiplicity in the meaning of the term. In reflective science writing, presentations of the theory often try to form a balance between chaos as a source of order on the one hand, and the connotations of disorder on the other, and suggest that what chaos theory actually does is to open up a space between the concepts of order and disorder. As Cordle (1999: 87-88) notes, '[t]he result is a see-saw between two representations of reality: The first assumes a sharp binary distinction between order and disorder, and the second finds this distinction to be less meaningful'. This blurring of order and disorder is manifest in particular kinds of oxymoronic rhetorical devices: 'two antonyms are harnessed as adjectives to describe the same noun [e.g. 'fuzzy and detailed', 'structured and unpredictable' from Feigenbaum], or one word is deployed as an adjective to a describe a noun, normally associated

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[27] Weingart and Maasen themselves focus on the adoption of 'chaos' into the discourses of the social sciences. They perceive the same reactions to the use of the term in the social sciences as appear in literary studies: some commentators are applauding the metaphorical usage as fruitful, whereas others deplore the usage as being 'merely' metaphorical and thus only creating confusion in the reader (Weingart and Maasen 1997: 474).

with an opposite meaning to that adjective [e.g. 'deterministic chaos', 'orderly disorder' (Lorenz), 'stable chaos' (Marcus), 'regular irregularity' (Mandelbrot)]' (Cordle 1999: 87-88).

The more popular chaos theory became outside the context of pure natural sciences, however, the less interested scientists were in using a term so fraught with cultural associations, and 'chaos' came to be seen as the popular name of a part of what is called 'nonlinear dynamics' or 'dynamical systems theory' in scientific usage (Stewart 1989/1997: vii-viii, see also Hayles 1990: 8-9). But in literary discussions the thermodynamic implications of 'chaos' as disorder continue to influence the ways in which the science is understood. Peter Francis Mackey (1999: 37), for example, while acknowledging that scientists are turning away from using 'chaos', decides to stick to the term exactly because the dual meaning of both generative void and disorder proper resonates with his reading of James Joyce's *Ulysses*:

> in suggesting a void as well as utter confusion, 'chaos' provides too useful a description of three aspects of *Ulysses* to forgo it: (1) the way the life of its central character, Bloom, emerges for us out of nothing as he enters and lives through *Ulysses*; (2) the confusion that greets first-time readers of this demanding novel; and (3) the similarities between Bloom's encounter with life and ours.

Most literary scholars have interpreted some form of generative void, existing between order and disorder, as the most interesting aspect of chaos theory. By alternating between expressions of order and disorder, scholars refer to a third, alternative conceptualisation of reality, and thus orderly disorder is viewed by, for example, Demastes (1998: xi) as a middle ground between the unbearable opposites of 'static tedium' and 'random frenzy' in the universe.

The bleeding of these different meanings of 'chaos' from one context to another has been both applauded and objected to. Scientists themselves have argued for specificity and for keeping the term clean of extra-contextual meanings. When discussing the development of the term with Ken Baake, John Casti, for example, argues that adopting a word with everyday connotations in scien-

tific usage requires 'sucking out or dramatically restricting in all variety of ways the kinds of interpretations that it has in informal everyday language' (as quoted in Baake 2003: 102). Similar opinions can be found even in literary studies: Willie van Peer (1998: 45) firmly believes that the everyday sense of the word must not be allowed to seep into our understanding of what chaos theory actually means within the context of a scientific text. Many cultural theorists and literary critics, however, have criticised scientists not only for attempting to limit the use of 'chaos' outside its scientific context, but also for abandoning the term within scientific discourse when its cultural baggage was deemed too overwhelming. Rather than imagine that it is possible to keep the cultural meanings out of any text where a term that has a history outside its scientific context is used, they argue that no such sterilisation of meaning is possible or even desirable. Demastes (1998: 8-9), for example, dismisses the scientists' decision not to use the term and claims that the 'richness and complexity' of it is exactly what should be paid attention to.

However, I would emphasise that contextual limitation of meaning is not only possible, but both necessary and common in all language use (see e.g. Sperber and Wilson 1986/2004). If literary scholars decide to ignore the contextual indicators of relevance when interpreting the meaning of a metaphor in a scientific text, they could also be said to dismiss the entire natural scientific world-view which forms that context, and to bracket out of discussion exactly those parts of the model which make the metaphor mean something in that context. To implicitly assume, as Demastes seems to do, that science would benefit from continuing to use a heuristic metaphor at a point where scientists believe it has served its purpose and expanded beyond the current needs of the theory, is perhaps to assume that the kind of proliferation of meaning considered valuable in literature is also valuable in science – an assumption that may itself arise from regarding science as text.

Explanatory Metaphors in Science Writing

Even though the purely rhetorical analysis of professional and reflective science writing rarely has transdisciplinary aims, in the background of the view of science as text may lurk the more ambitious assumption that science as a whole can be reduced to an object of literary and cultural analysis. When it does appear, such an assumption tends to be connected to an unwillingness to acknowledge differences between professional science and reflective texts. For example, most literary scholars derive their understanding of chaos theory from works of reflective science writing, but, especially considering that they are professional analysts of texts, they occasionally show a lack of critical focus as to the epistemological status of their sources.

One problem is confusing the explication of a theory with the application of it. Ward (1998: 117-118), for example, argues that demands for mathematical methods in literary applications of chaos theory are ungrounded because popular science books have demonstrated the ease with which metaphorical language transmits the central ideas of chaos theory, without needing to rely on mathematics. It is clear, however, that reflective science writing avoids mathematics in order to stay popular, not because metaphors are inherently better at describing chaotic phenomena. Reflective science writing consists of the translation of the original discoveries from mathematics into a natural language, made for the benefit of those who do not 'speak' the original. They are expressions *of* mathematics but are not *mathematics*. The radical difference between natural language and mathematical notation was remarked upon already by Werner Heisenberg (1967/1989: 169) who warned his readers that using natural language to describe quantum mechanics is bound to be inaccurate: 'it is not a precise language in which one could use the normal logical patterns; it is a language that produces pictures in our mind, but together with them the notion that the pictures have only a vague connection with reality, that they represent only a tendency toward reality'.

The conflict that arises from these different interpretations of reflective science writing draws on two different conceptions of the purpose of scientific writing in general: the scientists believe that even reflective science writing is supposed to impart to the reader knowledge of specific natural phenomena and therefore the words should be understood within the scientific context, whereas cultural theorists wish to unhook the text from its author's original intention and allow connotations which might increase the dissemination of the text's meaning. As Beer (1996: 159-160, 181-184) has argued, even though within the natural sciences technical terms are treated often much more like mathematical symbols than words in a natural language, the scientist author cannot enforce that restriction. As emphasised above, the discourse of science rests, rather, on the assumption that 'the attempt to control levels of statement and description must depend more upon the agreement of a close professional community' (Beer 1996: 159). That is, it relies upon the audience understanding the restricted context of the expression and actively repressing any other associations aroused by the term. However, as Beer (1996: 164) points out, from the perspective of interpretation the meaning of even scientific texts can no longer be restricted by the author once they have been published, and exploratory misreadings are perfectly possible and legitimate (see also Waugh 2005: 236).

Literary works, naturally, have always played with the scientific discoveries of their time, and few would be as churlish as deny them the right to extend the scientific metaphors to new, imaginative directions. However, even when it is admitted that metaphorical extensions within works of literature have their own intrinsic value, their legitimacy in the context of literary analysis is another issue. Much depends on the nature of the difference, referred to in the Introduction, between literature as an art form and as a scholarly pursuit. Although Beer (1996: 164) correctly defends the literary authors' right to extend the implications of scientific metaphors for artistic purposes, she does not take an explicit stand on the role of literary analysis. To be sure, there is not

much point for a literary scholar to approach scientific texts and aim only to reproduce the knowledge and attitudes already present in the production of that text. Thus Gillespie (2003: 34), for example, points out that 'the discoveries of post-Einsteinian science offer even more to humanists when they apply the concepts in a fashion suited to the protocols of their discipline rather than according to strictures imposed by the hard sciences'. Such exploratory research based on a deliberate misreading can be valuable for literary studies, and is perhaps best achieved by using the toolbox of our own discipline. But it is also vital to remain aware of the fact that the transformations in the meanings of scientific terminology that result from removing them from their original context cannot, afterwards, be attributed to the science. Conceptual baggage carried by a term in everyday language belongs to the context of everyday language. Judging from the use of chaos theory in literary scholarship, I would argue that literary scholars have often assumed the amalgamated position between the scientific reference of the original text and a literary proliferation of the metaphors: they read scientific texts as literary authors do, but produce texts in which the scientific reference is still assumed to remain valid, even though the meaning of the metaphors has been extended beyond the original, constricting context.

Science as Textuality

A more radical view of science as text considers it in the post-structuralist paradigm of textuality. Peter Stoicheff goes far in talking about science as discourse on a par with literature, and takes the new conceptualisations of order and disorder as reasons for dismantling what he sees as a long-established hierarchy of value between them. Because the 'margin' between the text and the world is ruled by the chaotic dynamics of language, Stoicheff (1991: 86) suggests, any realistic attempt to represent it only results in an illusion, whereas metafiction, because of its self-reflection and resistance to comprehensive meaning, actually represents that relationship in an accurate fashion. Stoicheff's view of

chaos theory and metafiction is seen from a perspective which 'examines the similar roles of narrative and investigative procedure', and which presents scientific inquiry as one of '[o]ur worldly narratives, through which we construct what we think of as reality' (Stoicheff 1991: 85, 95). This position subjects the concepts of chaos theory to analysis which expressly does not allow their original context any special authority.[28]

Since my focus is on the humanist end of the chaos spectrum, however, I will not discuss this poststructuralist interpretation of chaos in any detail. However, a point I would like to raise is the contrast between such a view and the more conservative rhetorical analysis of scientific texts. Most importantly, there are cultural and ethical implications embedded in the different ways of conceptualising the relationship between the natural sciences and humanist research. A central text in this respect is Patricia Waugh's essay 'Just-So Stories? Science, Narrative, and Postmodern Intertextualities' (2005), in which she argues that the poststructuralist theories of language and current developments in the natural sciences actually support each other in creating a new grand narrative of textuality. This surprising but prescient claim is based on Waugh's analysis of the 'scriptoral metaphor' which she sees as affecting both the sciences and the arts in the twenty-first century. Poststructuralism, by presenting literature and culture as a play of intertextualities, and current biochemistry and neo-Darwinist sociobiology, by presenting nature as ruled by the code of DNA, both create a view of all being as 'an autopoetic invention, a writing which writes itself, liberated both from demiurges and authors' (Waugh 2005: 243). What follows from the expansion of this metaphor, Waugh (2005: 239-242) argues, is a blurring of the fact-value distinction which has kept scientists from making the leap from what they know to be the case to what they

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[28] In the same collection Knoespel (1991) also discusses chaos as a form of discourse and compares it with deconstruction. Knoespel argues that even though deconstruction and chaos theory differ both institutionally and epistemologically, a narratological analysis reveals that both rely on the rhetorical strategy of examples.

think ought to be the case. If the autonomy of the worlds of science and art succumbs to the 'condition of pervasive textuality', Waugh suggests, and all becomes story, postmodernism actually ends up smoothing the way for the 'expansionist turn' in science by strengthening the vision of life as code that can be cracked and even modified:

> Evolutionary theory [...] may consequently explain how the algorithmic mechanism of natural selection has fashioned from this universal grammar the neural networks of the human mind, the principles of human culture, and the behaviors and impulses of all living organisms. Science is therefore licensed to pronounce on value. (Waugh 2005: 242)[29]

The reason why I want to bring up Waugh's argument at this point is to emphasise that, in contrast with the poststructuralist scriptoral metaphor, the humanist perspective does not fall into the trap of enabling scientific expansion while attempting to undermine the premises of that expansion. In the following section I will argue that the third conceptualisation of the science metaphor, science as knowledge, opens up the possibility for an approach that keeps the sciences from extending their purview from 'is' to 'ought', while it at the same time respects their expertise on physical reality. It is possible to find in the theoretical discussion on literature and chaos ways of approaching the sciences that make them relevant to the humanities but do not allow one to subsume the other, and that do not deconstruct the autonomy of the sciences as a form of genuine inquiry.

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[29] See also Paulson (2001b: 82-83)

1.3   Conceptual Metaphor: Science as Knowledge

> Why stretch and twist, press and expand, concepts
> in this way – Why try to see A as metaphorically B,
> when it literally is not B? Well, because we *can* do
> so, conceptual boundaries not being rigid, but elas-
> tic and permeable; and because we often need to do
> so, the available literal resources of the language be-
> ing insufficient to express our sense of the rich cor-
> respondences, interrelations, and analogies of do-
> mains conventionally separated; and because meta-
> phorical thought and utterance sometimes embody
> insight expressible in no other fashion.
>
> <div align="right">Max Black, 'More About Metaphor'</div>

Whereas previous sections presented examples of literary scholars' attitudes towards the natural sciences which aimed either at effecting a change in the natural sciences or even at explaining the natural sciences through the methodology of literary studies, this section will focus on the work of scholars who regard the metaphorical use of chaos theory as a way of changing the methodology of their own field. Furthermore, even though there were doubts expressed in the previous section as to whether metaphor can convey knowledge that has been formulated in the language of mathematics, in this section I try to see to what extent it could indeed carry the kind of knowledge difficult or even impossible to convey in any other form of natural language.

In the field of chaos theory and literature the most complex interdisciplinary positions are held by scholars who aim, through metaphorical use of the terminology of chaos theory, to destabilise the borders between different forms of knowledge, and thus change the methods of literary studies themselves. Underlying this kind of thinking is the conceptualisation of 'science' as the knowledge that has come out of scientific research. In this section I will focus on the work of Michael Patrick Gillespie and William Paulson who both argue that the knowledge that chaos theory has produced concerning the behaviour of dynamical systems changes

the way causality should be understood. Such a change would not affect only mathematics and physics, but all forms of human thought, including literary analysis, even though it has not (at least yet) been established that dynamical systems theory and its discoveries are directly applicable to cultural systems. The reason why these scholars take the metaphorical adoption of chaos theory into literature to be fruitful is that they, like Max Black above, believe that metaphorical meaning can be irreducible. The phrase 'conceptual metaphor' in the title of this section thus refers to a genuinely new semantic entity which can carry a meaning that is not expressible by any paraphrase, i.e. it is not a heuristic which can be abandoned once a more precise expression is formulated. Thus these critics argue that the metaphorical combination of chaos and literature would make a certain kind of thinking about literature possible.

I, too, agree with Black's suggestion and argue that some metaphors can convey ideas in a way that no other expression can. However, I also would like to distinguish between conceptual metaphors that are, indeed, inexpressible in any other way, and the scientific concepts expressible in no other form of *natural* language, but which are initially formulated as knowledge about the world in the language of mathematics. The reason for this distinction is pragmatic: I am not qualified to pronounce on the meaning of mathematical statements, nor is their inclusion here necessary, since the importance of conceptual metaphor can be established even without extending the theory beyond natural language. With this caveat in mind, I suggest in the following that interdisciplinary metaphors, when they understand 'science' as knowledge about physical reality, can clarify the relationship between the natural sciences and literary studies as disciplines. The meeting of different disciplines can then be conceptualised as an encounter with otherness, where the respect felt for the other discipline is built into the metaphorical uses to which its world-view is being put.

Chaos as Conceptual Resource

As discussed above, Matheson and Kirchoff's argument against the use of chaos as a metaphor denied that any truly new knowledge can be produced by modelling literature as chaos. However, the problem in their argument is that they take literature to mean only specific literary works, whereas many other critics have suggested that metaphorical uses of chaos theory precisely can help us to learn more about literature and its study as general phenomena. For example, Weingart and Maasen (1997: 478-479, 518) have suggested that examining the uses of the chaos metaphor in the social sciences reveals that the metaphoric transfer of knowledge is itself a chaotic process in which the different uses of the 'hybrid' metaphor of chaos form a feedback loop through which 'chaos has assumed ever-increasing semantic facets, rendering (aspects of) it more and more attractive'.[30] Whether or not we accept the claim that interdisciplinary knowledge is at its root a chaotic process, Weingart and Maasen's point is valid in emphasising the possibility that interdisciplinary metaphor is capable of generating new knowledge.

The basis of such a view of metaphor was suggested – from as early as the 1980s – by Black, whose 'strong creativity thesis' stated that some metaphors create similarities rather than just describe existing ones, making 'connections that, once perceived, are *then* truly present' (1980/1993: 37). More recently the view has been extended and made popular by the conceptual metaphor theory of George Lakoff, Mark Johnson, Mark Turner and Gilles Fauconnier.[31] One central idea in conceptual metaphor is the blending process, whereby the characteristics of a source domain are mapped onto a target domain to create a conceptual structure not quite like either the source or the target, and which can change the way both the source and the target are understood.

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[30] In this their approach is very similar to that of Hayles (see p. 46).

[31] See e.g. Lakoff and Johnson (1980), Lakoff and Turner (1989), Fauconnier and Turner (2002).

From this perspective chaos theory in literary studies appears as the conceptual metaphor LITERATURE IS A CHAOTIC SYSTEM, a notion that cannot be formulated or understood in any other than metaphorical terms. Such an approach aims at taking chaos theory as a source domain and using its fusion with literature (the target domain) as a way of reconceptualising both literature as a phenomenon and the methods used in its study. For example, Gillespie suggests in *The Aesthetics of Chaos* (2003) that chaos theory should be used to reveal the nonlinear patterns of reading which are obscured by the argumentative structure of the critical essay. Rather than positing that the literary texts in themselves would necessarily be chaotic, Gillespie (2003: 34) argues that 'patterns of reading for almost everyone adhere to an epistemology shaped by nonlinear complexity' and that 'formal criticisms that do not reflect that condition simply fail to address aesthetic experience'. Thus he suggests that critics could (and should) learn to display in their readings a more comprehensive, though necessarily less coherent view of the literary work:

> What I am advocating here is not a reconfiguration in our habits of reading but rather a new awareness of what we already do. Sophisticated readers have learned to balance ambiguity with such dexterity that the process moves forward without conscious effort. So far, formal criticism has not generated a metaphoric system that can articulate the complexities of that process. My efforts do not aim to dismiss the achievements of previous critics but rather to introduce a vocabulary and an analytic method that allows expansion of existing formal responses to literature. (Gillespie 2003: 25)

According to Gillespie (2003: 110-111), the metaphorical system offered by chaos theory not only provides critics with a vocabulary to express the ambiguity of readings, but it also boosts their credibility by matching their argument with suitable rhetoric. By concentrating on nonlinearity chaos theory has drawn attention to the disproportionally large effects of small causes and, by implication, to a multiplicity of responses to literature. Thus, as long as natural language is ruled by the metaphorical system of cause and

effect, Gillespie (2003: 30) suggests, the desired 'pursuit of ambiguity' will be frustrated.

I take Gillespie's work as an example of a theory that adopts the knowledge produced by the sciences as a metaphor for literary analysis. The connection formed between the two fields of study functions as a conceptual metaphor which, rather than focusing on the scientific process or science as discourse, suggests that the knowledge produced by scientific activity can cause a new conceptualisation of what literary criticism can and should be. I should note, however, that Gillespie's argument rests on the assumption that the task of scholarly reading is to reconstruct the reading experience, and that the difference he observes between 'the cognitive process followed by a reader' and the method displayed in literary analysis automatically 'challenges the relevance of traditional interpretive commentary' (Gillespie 2003: 4).[32] Below I will suggest that Gillespie is too hasty in dismissing more traditional forms of interpretation and that metaphorical interdisciplinarity may, indeed, benefit from their methods and perspectives.

The conceptual metaphor LITERATURE IS A CHAOTIC SYSTEM opens certain issues to discussion that may have been thought to have been exhaustively analysed and defined, not only because it emphasises certain characteristics in literature that are also found in chaotic systems, but also because once that metaphor is examined and queried, certain things are seen *not* to match. Daniela M. Bailer-Jones (2002: 112, 120) makes the point of emphasising that the power of metaphor as a theory-constitutive device depends on it being open to critique. 'The effective use of analogy presupposes that its users know, or can explore, what the positive and

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[32] Also, while Gillespie admits to his own writing occasionally being too logical and linear to match his own arguments, his real failing is in the literary readings. His analysis of *Finnegans Wake*, for example, is limited to relating the gists of previous readings and commentaries on, for example, the multiple allusions in the text, and then exhorting future critics not to choose between them. He attempts to describe the experience of thinking about several things simultaneously, but ends up just prescribing it (Gillespie 2003: 34-42).

the negative analogies between two domains are', Bailer-Jones notes. 'Knowing what the model is not a model of is part of the model'. This negative comparison is also seen to be central to the development of interdisciplinary research by Beer (1996: 195), who argues that in order to count as successful, interdisciplinarity does not always need to find similarities and reconciliations, but rather, 'transformations and imbalances reveal as much as congruities'.

In the case of chaos theory and literature, the problem is that the negative analogies tend to be ignored and the neutral analogies are used to support claims that are to all intents and purposes unfalsifiable. There is no way in which the claim that a literary work is a chaotic system could be falsified, since the mathematical methods for identifying chaotic systems cannot be applied to literary works. Therefore, however useful metaphors and analogies between different disciplines can be for conceptualisation, critics and theorists using them should also show an awareness that even the most intriguing metaphorical connection does not establish a real interdisciplinary link (in the sense defined by Klein; see pp. 20-21) between two fields of research. Similarly, the way that the previous interpretations of chaos theory within literary studies have emphasised its revolutionary status, and have been blind to those aspects of chaos theory which do not match their vision of the erosion of scientific epistemology, shows that they have been uninterested in exploring the differences between their model of literature and that presented by chaos theory.[33]

William Paulson is a scholar whose approach to literature very much emphasises the interpretive act, and who explicitly extends his understanding of the dynamics of interpretation to interdisciplinary interactions. Like Gillespie, he is interested in complexifying prevalent notions of causality, but instead of focusing

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[33] I should stress that since my aim is to bring out certain aspects of the chaos and literature discussion that have been left in the shade, not to provide a complete, alternative metaphorical model for that discussion, I also refrain from making actual comparisons between literature and chaotic systems, whether positive or negative.

on making scholarship reflect the multiplicity of interpretations, he argues that interpretations should approach the literary work as an object external to the interpreter, even while being aware of the implicatedness of the interpreter in the hermeneutic process. In 'Literature, Complexity, Interdisciplinarity', his contribution to Hayles's 1991 volume, Paulson presents different disciplines as a hierarchy of descriptive levels, where interdisciplinarity would entail moving between levels or choosing an unusual level of descriptive reduction for a particular phenomenon. From this point of view, the benefit of introducing scientific vocabulary in the study of literature would be the production of new knowledge from the noise created in the interaction of two such different forms of discourse.[34]

> If I practice interdisciplinarity by importing terms and concepts such as those of information theory and self-organization, violating conventional boundaries by identifying textual ambiguity and rhetoricity with noise, I do so not to produce a Grand Synthesis but to disturb, enrich, and perhaps displace the study of literature by injecting into it some information sufficiently foreign as to function initially as 'noise, the only possible source of new patterns'. (Paulson 1991: 49, quoting Gregory Bateson)

Thus Paulson, like Gillespie, aims to destabilise the assumptions prevalent in literary studies. He also explicitly equates literature with literary study as a discipline, and suggests that as forms of knowledge both differ from the scientific endeavour in their ability to deal with several levels of description simultaneously (Paulson 1991: 46-47). Therefore literature, by being able to comment on several layers of reality, is able to refer both to itself and to reality without having to exclude either. What the sciences of complexity have done, Paulson (1991: 51) argues, is to add to the toolkit of the literary scholar 'new kinds of concepts of causality', in particular the idea of emergence, which then change the way the context of literary works, 'our material, organic, and social world', is understood. I find Paulson's work to be a valuable ex-

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[34] For a further discussion of the role of information theory and the concept of noise in literary studies see Paulson (1988).

ception in that he manages to present an argument where litera-
ture both differs from the epistemology of the natural sciences
and remains connected to reality.

Encountering Science

Ten years later, in an essay titled 'For a Cosmopolitical Philology:
Lessons from Science Studies' (2001a), Paulson formulates an im-
portant addition to his theory of postmodern, interdisciplinary lit-
erary analysis, and one that might change the metaphor for inter-
disciplinarity from war to diplomacy. He begins by reiterating the
point about the importance of context to literary phenomena.
'One crucial reason for doing "literature and science"', Paulson
(2001a: 101-102) argues, 'is to help literary studies [...] fit into a
world where nonhuman things matter'. Therefore any kind of
scholarship that wishes to go beyond pure formalism needs to
work out how cultural objects connect to material reality, 'how
our cultural texts fit into collectives that are not just cultural'.
What Paulson would like the humanities to adopt is a method of
investigating text as something which is (at least to a large extent)
independent of the researcher's will, and create theories which can
(at least up to a point) be falsified. 'What matters', he (2001a: 112)
argues, 'is that the knowledge and assumptions of the knower be
put at risk: that whatever the knower is interacting with have the
power to make a difference in the process'.[35] This power given to
the object of research to deny the researcher's assumptions and to
resist the very interpretation that is being constructed, leads to a
'cosmopolitical philology', itself based on Isabelle Stengers's pro-
ject of defining for the human sciences an 'ecology of practices'
towards the other, of 'encountering one's "object" as a fellow
human "subject"':

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[35] See also Umberto Eco, who separates 'interpreting' texts from 'using'
texts (1992b: 68-69) and introduces a principle of falsification to the evalua-
tion of interpretations (1992a: 52).

> To interact sociably with a text is to posit that it is the delegate of
> a person, even if we are obliged to (or think it wiser to) construct
> that person entirely from the evidence of the text. Our respect
> for the 'ghost' and its intentions may enable us to respect the
> text's resistance, and keep us from taking it as simply an occasion
> for our own critical constructive performance. (Paulson 2001a:
> 115)

Paulson, then, is willing to transgress disciplinary boundaries, but does so in order to change the methods of his own discipline, rather than impose his own methodology on another. In particular, he introduces the idea of falsification into contemporary literary studies in the shape of giving the literary work a position as a member of a communicative situation, as an entity with the (at least hypothesised) capacity to claim a reading to be wrong.

The idea of an encounter with another being can itself be seen to be at the root of metaphorical meaning. Roger D. Sell (2000: 250) argues that literary encounters are like metaphors because they 'raise possibilities, open up new perceptions, generate enquiry'. Similarly, I would suggest that scientific metaphors at their best are what literary encounters should be: models where there is space left for what the model is not a model of, or meeting points between two fields of knowledge where both elements of the metaphorical blend are allowed a voice and the possibility of saying 'no, this misrepresents me'. I realise that my own rhetoric is slipping into dangerously anthropomorphised ways of presenting abstract concepts, but, fittingly, the metaphor of an encounter of equals carries meanings that are difficult to express otherwise.

This irreducibility is one of the central meanings of the word 'texture' in the title of this study. Metaphorical uses of scientific knowledge create meanings that, whether they occur within the context of scientific, literary or theoretical texts, can only be approached through a combination of analysis and interpretation. This is why the tasks designed by Cordle (1999) for literary investigation into science (tracing influences and shared metaphors, rhetorical analyses of scientific texts, and the larger philosophical questions of what counts as knowledge in the different fields; see

p. 50), all retain their basis in interpretation. This position offers the possibility of seeing science and the knowledge it produces as connected to, but not completely encompassed by the study of culture and meaning. A similar argument has been presented by Martin Eger (1993: 205), who suggests that even though the highly formal expressions of mathematics lie beyond hermeneutic practice, the texts produced in natural language do not, but rather consist of concepts and metaphors that 'come to us with a context and a history'. Therefore both the texts produced by scientific activity and the knowledge presented in them through culturally contextualised language are subject to interpretation.

Conversely, however, the extension of interpretive issues into the field of scientific texts can be understood to mean that scientific knowledge is able, in an unprecedented manner, to pronounce on value. At the end of the previous section I referred to Patricia Waugh's (2005) criticism of the sciences are expanding their purview from 'is' to 'ought'. A similar argument has also been formulated by Slavoj Žižek (2002), who focuses on the 'Third Culture', a community of scientists brought together by publisher John Brockman, which attempts to merge the latest scientific discoveries with the age-old questions of what it means to be human, and to do so through reflective science writing in a fashion that is understandable to the general audience.[36] These writings have won a lot of ground from cultural studies, argues Žižek (2002: 20-22), who points out the vast popularity of the Third Culture authors compared to those representing cultural studies. He also notes the 'missionary zeal' of the scientists in building a new paradigm of knowledge, and suggests that they have not shown any sensitivity to the complexities of ideological debates (Žižek 2002: 22-23). On the other hand, the Third Culture writers obviously have revitalised the discussion by bringing back the kinds of metaphysical questions cultural studies has bracketed. 'So in clear contrast to the strict prohibition of direct

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[36] Third Culture members include, among others, Richard Dawkins, Daniel C. Dennett, Murray Gell-Mann, Stuart Kauffman, Lynn Margulis, Marvin Minsky, Steven Pinker and Francisco Varela (Brockman 1995).

ontological questions in cultural studies', Žižek (2002: 26) suggests,

> the proponents of Third Culture unabashedly approach the most fundamental pre-Kantian metaphysical issues (such as the ultimate constituents of reality, the origins and end of the universe, the nature of consciousness, and the emergence of life) as if the old dream which died with the demise of Hegelianism, of a large synthesis of metaphysics and science, the dream of a global theory of *all* grounded in exact scientific insights, is coming alive again.

Although considering such metaphysics an important area of thought, Žižek (2002: 27-28) argues that the Third Culture and its members are blind to the difference between 'knowledge inherent to the academic institution, defined by the standards of professionalism' and 'the truth of a (collective) subject engaged in a struggle'.

Taking Waugh's and Žižek's criticism into account it could be said that, on the one hand, reflective science writing has provided literary and cultural studies with new, enriching metaphors, but, on the other hand, it has confused descriptive and prescriptive ways of talking about reality and about human values. At the same time as cultural studies have been adopting scientific metaphors, the writers of the Third Culture have also been busy utilising those metaphors in texts that seem to have much more influence on the current *Zeitgeist* among the general public than cultural theory does. While it is true that this constitutes an encroachment of the natural sciences into discussions usually reserved for the humanities, the solution is not only to dismiss those texts as unintellectual and lacking in theoretical understanding, but to approach them as reflective science writing, as writing which takes knowledge produced by the natural sciences and through the use of conceptual metaphors attempts to pronounce on issues relating to human culture and values. Only if literary and cultural scholars themselves are able to make this distinction can the general audience do the same and, consequently, keep in focus the difference

between scientific pronouncements on what is and reflective pronouncements on what ought to be.

Similarly, it is clear that the humanities must not allow the sciences to pronounce alone on the human value of their discoveries. Eger (1993: 188-189) brings up the 'ancient practice of scientific study for the sake of self-formation'. This connection between the scientific world-view and the values of an individual is reopened, Eger argues, not because of people undertaking actual scientific inquiry, but through the process of contextualising lives within the physical universe. This process, Eger (1993: 202-203) further suggests, functions through metaphor:

> although we do understand that a knowledge of stellar structure cannot affect our self-concept *directly*, that nonequilibrium thermodynamics will not give purpose to life, we are beginning to realize that this is not the end of the matter. For it is not *in themselves* that these bits of knowledge exert their effect; today they do so through the *metaphors* they support, especially the high-level metaphors – extrapolations and integrative appropriations of many disciplines. Through *this* channel the sciences do indeed have action-orienting power.

Thus the natural sciences can be producers of 'socially orienting theory' and blur the borderline between the 'value spheres' of the human and the natural sciences (Eger 1993: 203). For as long as the humanities dismiss the sciences altogether as a conversational partner they leave reflective science writing to carry on shaping the cultural meanings of scientific knowledge. Instead, by encountering the scientific knowledge as a conversational partner the humanities are in a much better position to critique the value judgements being made on the basis of that knowledge.

Conclusion: The Ends of Metaphor

'Metaphors [...] are not called fertile or generative for nothing', notes Ellen Spolsky (2003: 161).

> They breed promiscuously in the brain, producing analogies among unconnected or incommensurable ideas. These analogies are not only illimitable in number; they cannot, in principle, be restrained semantically. It is hard to separate the legitimate off-spring from the bastards until it becomes clear that the latter are sterile.

Spolsky's reproductive metaphor changes the basis on which scientific metaphors are judged from legitimising their creation to observing their effects. Rather than arguing whether it is correct to create and to use a particular metaphor, it makes more sense for interdisciplinary literary scholars to analyse the usefulness of the conceptual structure produced by that metaphor. In this I lean towards interdisciplinary pragmatics and suggest that the lack of actual applications of the mathematical methods of chaos theory to literary phenomena should be taken as a strong indication of the reduced reproductive capabilities of LITERATURE IS A CHAOTIC SYSTEM.

However, this is not meant as a dismissal of either interdisciplinary literary studies in general, or those based on metaphorical transfers in particular. How, then, should scientific activity, as well as the texts and the knowledge produced by science be conceived of within literary studies? One important guideline is a certain level of humility towards the methods of and the information produced by other disciplines. As has been pointed out, becoming an expert in more than one field nowadays is nearly impossible, and for many people within the humanities, seeking the help of a scholar already familiar with the issues within another field of research is tantamount to selling out. 'Although any one of us may be specialists in our field', Conte (2002: 202) warns us, 'we become the latter-day equivalent of informational Luddites when faced with the expertise and guidance required to approach another field'. As long as the commentary on interdisciplinary pro-

jects tends towards dismissing the knowledge produced by the other side as irrelevant or misguided, rather than just difficult to master, there is going to be little change in this reaction.

I am not in a position to suggest how the natural sciences should change their approaches to interdisciplinary humanities. As far as my own field is concerned, however, I believe that, difficult as it is to define the various ontologies of different forms of literary discourse, literary scholars venturing into interdisciplinary fields should display just such a conscious awareness of the complexities within their own discipline and position their research accordingly, as well as use the tools they already have to contextualise, analyse and evaluate the scientific sources they use. But even this kind of 'disciplined' idea-swapping should not need the warlike rhetoric of transgression and transdisciplinarity to justify itself.

To conclude, it is clear that there are intriguing similarities between the ways in which nonlinear mathematics is able to describe the complexity of the universe and the ways in which literary scholars attempt to capture the complexity of a text, and metaphorical connections drawn on such similarities can be an important source of inspiration for a scholar in either field. However, some theorists and critics working with chaos theory and literature have declared, with very little actual evidence, that chaos theory is the next universal explanatory model, suggesting that the equations of nonlinear dynamics describe everything from the movement of matter to the emergence of literary meaning.

On the other hand, chaos theory has in literary studies drawn attention to ways in which literary culture could oppose the developments noted by Waugh (2005) and Žižek (2002). The use of chaos theory as a metaphor for literature (either the textual object or the process of reading) can re-engage literary scholars in the issues of ontology and value which poststructuralist theory has seemed to bracket from discussion, and which have to some extent been taken over by reflective science writing, with arguably less than sufficient sensibility. Therefore, as long as literary scholars retain one eye on those aspects of metaphorical models that

do not match, it is possible and commendable to try to engage in the context of literary studies the questions thrown up by the natural sciences, and not leave the entire field of human value to be discussed by the reflective science writers alone.

Although it is common for abstract theorizing and speculation to outrun the applicability of the new ideas to detailed analysis, there is, undeniably, groundbreaking work being done in many disciplinary margins. It is therefore important to acknowledge the heuristic benefits of cross-disciplinary metaphors, as long as their ends, both in the sense of underlying goals and of limitations, are kept in sight. The following chapters, therefore, analyse the ways in which chaos theory has been adapted to the field of literature, but with the specific aim of focusing on the larger questions authors and literary scholars have attempted to answer with its help.

2. Strange Attractors in Literature: Constraints on Form and Meaning

> HANNAH This feedback, is it a way of making pictures of forms in nature? Just tell me if it is or it isn't.
> VALENTINE (*Irritated*) To *me* it is. Pictures of turbulence – growth – change – creation – it's not a way of drawing an elephant, for God's sake!
>
> Tom Stoppard, *Arcadia*

One of the most prominent characteristics of chaotic systems is that they display symmetry across scales. This is visualised in computer graphics as the many-coloured fractal marvels and looping trajectories of strange attractors (see illustrations on pages 7-8). Such graphs keep on repeating similar shapes on different levels of magnification so that, however closely a fractal picture is examined – however great the zoom factor – the deep structure does not reveal either homogeneity or irregularity, but shows a high degree of organisation that occurs on each level throughout the graph. The suggestion of chaos theory is that such self-similarity is a crucial governing rule in the function of the entire universe, and that certain patterns occur on every scale of dynamical behaviour, from gas molecules to stock-market prices.

What makes such graphs special, however, is not only their beauty or their visual resemblance, particularly in the case of fractal landscapes, to physical reality, but also the fact that they turn dynamic behaviour into visual models. As Stoppard's mathematician says in the epigraph, a strange attractor is not 'a way of drawing an elephant' but a way of visualising dynamics that appear in the natural world. Similarly, a fractal is not a picture of a fern or a mountain, but a graphic representation of a mathematical object – although ferns and mountains themselves do possess fractal characteristics. Because of this ability to graph complex behaviour in geometrical forms, chaos theory has been seen as a tool with which both the details of literary form and even the process of

making meaning might be visualised and thus be rendered comprehensible.

In chapter 1 I referred to Matheson and Kirchoff's list of possible reasons as to why literary scholars would want to create analogies between literary works and chaos theory. One of these reasons was that 'B is structurally similar to A, and this is inherently interesting' (Matheson and Kirchoff 1997: 41). Although Matheson and Kirchoff themselves are dismissive of this, as they are of all the other reasons for the use of chaos metaphors in literary studies, many scholars have discussed the structural similarities between literature and chaos, and have found them useful in constructing their interpretations. In this chapter, while not attempting to mine the indefinable and perhaps nonexistent gaps between form, content and meaning, I will approach the humanist conceptualisations of literature via the question of form before concentrating in chapter 3 on the emergent self as a source of meaning, and in chapter 4 on the relationship between both the form and the contents of literature and physical reality. Form is here defined pragmatically as the literary techniques used in a work, without attempting to claim that such techniques are strictly separate from the content manifested by them, or from the meaning that a particular content presented in a particular form has to readers and audiences. My aim is to show how the age-old dilemmas of literary ontology are present in the ways chaos theory has been used by authors and scholars, and to point out some ways in which the approaches representing the humanist perspective have tried to deal with them.

It has been proposed that the use of scientific concepts in literary studies only makes sense in the context of formal analysis. Michael H. Whitworth (2001: 3), for example, argues that scientific metaphors in works of literature only become interesting 'when they shape ideas about literary form' (Whitworth 2001: 3). In his volume on modernist literature and the theory of relativity, Whitworth explicitly attempts to limit his discussion to the effects science has had on literary form. By doing so, he believes he is not only reflecting the modernist interest in formal explanation but

also better able to make generalisations than if he was discussing the thematic contents of individual works (Whitworth 2001: 3-4).

Examples of a similar emphasis on structure rather than themes can be found in the approaches that use chaos theory. However, while scholars are keen to formulate theoretical statements about the ways in which chaotic structures could be reflected in literary forms, their actual analysis often focuses on thematic representations. In *Beautiful Chaos* Gordon E. Slethaug (2000: 164) specifically presents chaos theory to be most valuable as a structural principle: works with 'structures based upon models of chaotic activity', he argues, are inherently more interesting than those which, for instance, just include metaphors of chaos and order. Slethaug approaches various literary works through formal concepts based on different aspects of chaos theory, including fractals and strange attractors. His discussion includes many of the central elements of the humanist perspective on chaos theory and literature, and presents thought-provoking readings of several American postmodern novels. But while there is a clear focus on the forms of chaotic dynamics, Slethaug's book, in fact, gives more space to the way in which the forms of chaos appear in the content of his chosen works than to the characteristics of the narrative structures themselves.[37] In this Slethaug is not alone. The way in which critics slide from first conceptualising literary form through chaos theory to analysing not actual literary forms but general ideas about (not necessarily literary) structure which appear as themes in literary works, reveals a deep ambiguity as to what is meant by literary form and how its relation to meaning is conceived.

I would argue that this tendency to slide from theoretical conceptualisations of form to thematic analysis is due to at least two fundamental problems, one of which is interdisciplinary and the other intradisciplinary. Firstly, there is the difficulty of fitting

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[37] Slethaug's book does not engage recent narratological research at all, but refers to theorists who concentrate on postmodernism as a larger cultural field (e.g. Gilles Deleuze, Jean-François Lyotard, Michel Serres and Brian McHale).

literary works into the structural model provided by chaos theory, which in its original field requires strictly defined variables (however unpredictable the behaviour of those variables turns out to be). A strange attractor drawn by the complex behaviour of x's and y's still requires a scholar numerically to define some x's and y's. Since describing the structural qualities of a literary work in such terms is probably impossible, the analogy is suggestive but necessarily imprecise. Secondly, the conceptualisation of the literary object itself is so much in flux within literary studies that the chaos-influenced interpretations are understandably ambivalent as to the difference between form and content.

Most often the comparisons drawn between chaos theory and literary form tend to be superficial and less than innovative. There is not much novelty or explanatory force in Patrick Brady's description of the narrative structure of Marcel Proust's *In Search of Lost Time* as chaotic simply because 'the crucial but trivial incident of tasting that tea-cake (*madeleine*) soaked in tea [...] produces from his simple cup of tea the whole town of Combray with its gardens, and ultimately the entire huge novel' (Brady 1989: 186). Equally indistinct is the reason why Hilary Rhodes Bailey (2000) should need the concept of the strange attractor to describe the thematic complex of fate, determinism and free will in Denis Diderot's *Jacques the Fatalist and His Master*, rather than referring to it just as a 'unifying matrix' of three interwoven themes – an expression which she also uses (Bailey 2000: 59). This kind of scholarship is certainly susceptible to Matheson and Kirchoff's (1997: 42) criticism that in 'applied chaos theory' the interpretation presented could have been arrived at without the use of 'laboriously explained' chaos terminology.

However, while it now seems that chaos theory does not lend itself usefully to formal analysis as such, I suggest that the structural models based on chaos theory have inspired a particular kind of conceptualisation of literature that should be further developed within literary studies. What chaos theory can do when used as a conceptual tool is to help us to think of literature simultaneously in terms of structure and dynamics. Envisioning the literary work

as a peculiar hybrid between a process and an object, as a rhetorical entity that allows both for intended meaning and endless variations in interpretation, could be a way of combining humanist theories and postmodern literary forms. The ideas and values associated with humanism in this chapter are the pre-structuralist ideal of a literary work as a coherent whole and the romantic respect for it as an autonomous entity. These two strands of thought are combined with chaos theory's presentation of complex form and result in a re-evaluation of the romantic metaphor of the literary work as an autonomous organism.

My own readings of Stoppard and Barth in the last two sections of this chapter discuss both their narrative structures and their thematic handling of the idea of form. In John Barth's short story series *On With the Story* (1996/1997) reflective form and metafictional frame-breaking are utilised not in order to emphasise form over content and thus estrange readers from literary meaning, but in order to create a coherent whole in which form and content reflect each other. In Stoppard's case the analysis of form is immediately complicated by the fact that *Arcadia* is drama, not narrative fiction. However, I shall take my cue from Manfred Jahn (2001: 674) who has argued that plays can be analysed in much the same way as any other kinds of narrative in the sense that they 'have a story and a plot, and even if they do not literally "tell" their story, tellability and experientiality are dramatic criteria'. I shall therefore approach *Arcadia* mainly as a literary narrative, even though printed stage directions are also taken into account. As with Barth, the play can be seen to marry form and content by creating a narrative structure which reflects the thematic discussion of apparent chaos and emergent order.

The answer to the question of why chaos theory can be useful in comprehending the conundrum of form, content and meaning lies in the humanist aims of both the authors and the scholars discussed here. In order to combine contemporary literature with humanist concepts they present ways of discussing postmodern literary forms in terms other than those associated with disjunction and fracture. Since chaos theory is able to present seemingly

fragmented and unpredictable dynamics in visual forms that show coherence, harmony and even beauty, these shapes give authors and scholars new conceptual tools with which to present literary form as infinitely complex, yet describable. Further, they search for ways to describe the plural, yet bounded meaning of literary works, and they even establish an iconic connection between literary form and the dynamic function of reality. In fact, I would argue that the reason why the humanist scholars would search for answers to the questions of literary ontology outside the field of literary studies, or even philosophical aesthetics, is that their work is to a large extent a reaction to the widespread concept of textuality in literary studies. The fact that so many literary critics and scholars have drawn parallels between literary structure and dynamical systems, despite the difficulty of doing so profitably, reveals a deeply felt interest in physical reality and its relationship with verbal works of art.

2.1 The Literary Work as Object and Process

> A novel is a living thing, all one and continuous, like any other organism, and in proportion as it lives will it be found, I think, that in each of the parts there is something of each of the other parts.
>
> Henry James, 'The Art of Fiction'

> As an element in the world revealed by computer exploration, the strange attractor began as a mere possibility, marking a place where many great imaginations in the twentieth century had failed to go. Soon, when scientists saw what computers had to show, it seemed like a face they had been seeing everywhere, in the music of turbulent flows or in clouds scattered like veils across the sky. Nature was *constrained*. Disorder was channelled, it seemed, into patterns with some common underlying theme.
>
> James Gleick, *Chaos: Making a New Science*

This section focuses on how the literary scholars have approached the concept of form with the help of chaos theory. Is a literary work an autonomous object and its form therefore something 'continuous' and organic, as Henry James famously suggests? Or is it a complex process of meaning-making? Is literary form best conceptualised through spatial or temporal models? What my analysis of the writings on literature and chaos theory shows is that in addition to the poststructuralist approaches which link chaos to the fracturing of both form and meaning, there is another perspective which uses chaos theory to re-evaluate and re-institute the romantic metaphor of artworks as autonomous organisms.

One major difference between what I have termed the poststructuralist and the humanist approaches to chaos theory is the move from using mainly temporal models of literary form to focusing on spatial ones. In some sense this is a move back from open-ended postmodern narratological conceptualisations towards the older Jamesian tradition where narrative is seen in terms of framing and closure. This tradition and its 'geometric imaginary' has been strongly criticised by Andrew Gibson (1996), who argues with reference to Michel Serres, Jacques Derrida and Julia Kristeva that narratology's attachment to spatial models perforce bounds its horizon to 'a unitary, homogenous space, determined by and organised within a given set of constants' (Gibson 1996: 7). Thus it is hardly surprising that in the poststructuralist texts that build on the work of the theorists Gibson cites, the focus is on the fragmentation of postmodern narrative, and the most common metaphor used to describe such structures is nonlinear temporality. The term 'linear' is, of course, a familiar one for narratology and most scholars adopt a meaning for 'nonlinear' that entails a negation of the temporal and causal sequentiality generally referred to by the expression 'linear narrative'.

For instance, Thomas P. Weissert (1991) detects the contrast between linear and nonlinear in Jorge Luis Borges's short story 'The Garden of Forking Paths'. At the centre of the story there is a fictitious novel which consists of a series of narratives that seem to contradict each other. Only one of the characters of Borges's

story manages to realise the meaning of the novel – that instead of representing a normal linear temporality, it is a collection of alternative events. Thus linearity is here an aspect of narrative time – of a narrative moving through time in the direction of causality, whereas nonlinearity describes a narrative in which this traditional movement is broken: instead of a single time-line there are several possible universes. Weissert also suggests that even though the postmodern and subjective aspects of Borges's story-within-the-story can be fruitfully analysed by using the concepts of chaos theory, the narrative of 'The Garden of Forking Paths' itself finally turns back to order and determinism by making it clear that the nonlinearity of the fictitious novel is embedded in the constraining structure of Borges's story (Weissert 1991: 240). Thus Weissert equates chaotic structures with postmodern temporal fragmentation and the crafted representation of linear temporality with modernist order, and suggests that these are the two poles between which Borges's writing fluctuates.

It is clear, however, that the only structure actually present for Weissert to analyse is Borges's linear and modernist narrative. The nonlinearity of the fictitious novel can only be discussed thematically, since it is only described, not reproduced in Borges's text. Thus Weissert's analysis does not really get to grips with analysing a nonlinear narrative structure, even though it does provide interesting points about how such a structure can be thematised while using a more traditional narrative form.

David Porush (1991), on the other hand, sees nonlinearity both in the thematic elements and in the narrative structure of William Marshall's novel *Roadshow*. He points out the way the novel's detectives notice small clues which eventually will form the solution to a crime, and the way small explosions set by the criminals eventually lead to the complete gridlock of all traffic in Hong Kong. These plot elements, Porush (1991: 71) argues, can be equated with the butterfly effect of small events causing large-scale changes in the dynamics of the city. But he also suggests that Marshall's disjointed narrative technique – that is, the way the narrative 'leaps about with unexplained hiatuses and discontinuities in

discrete packets of uneven length (fluctuates nonlinearly) following no apparent order' – is similar to the unpredictability displayed by chaotic systems (Porush 1991: 70-71). What is more, the foreshadowing used in the novel, Porush argues, can be equated with the sensitive dependence on initial conditions, since those moments develop into disproportionately meaningful elements in the reader's mind as the narrative progresses (Porush 1991: 71). Thus Porush thinks it possible to use the terminology and concepts of nonlinear dynamics to shed light on particular kinds of narrative structures.

Porush's argument, even though it involves actual analysis of narrative techniques, leaves the reader asking what exactly is gained by introducing the concepts and vocabulary of chaos theory. The narrative structure he describes could have been approached with the existing tools of narratological analysis (temporal concepts such as order and duration of events, story time, discourse time and foreshadowing). But Porush is less interested in developing new analytical tools than in creating a conceptual structure whereby the presence of nonlinear dynamics in literary texts is revealed and, due to the universality of those dynamics, the difference between natural and artificial systems is blurred (Porush 1991: 74-75). Hence, Porush's text reflects his desire to emphasise the universality of nonlinear temporality, whereby the same dynamics are shown to be at work both in nature and in culture.

A similar impulse can be seen in Paulson's *The Noise of Culture* (1988), where the aim is to blur the boundary between natural and artificial expressly in order to re-evaluate the organicist metaphor and to integrate it to the postmodern conceptualisation of literature as a complex process of meaning-making. In doing so, Paulson constructs a humanist theory of literature in which the autonomy of the literary work does not imply that it is disconnected from its author or that its meaning is inaccessible to readers. Rather, in order to be meaningful, the literary work must be seen as an 'artificially autonomous' entity (Paulson 1988: 135). While Paulson's is the most comprehensive re-evaluation of chaos the-

ory and the organicist view of art, I will first look at the work of other scholars who have also, though less explicitly, moved in a similar direction in their interpretations of what chaos theory might mean for our conceptualisations of literary form.

Attractive Structures

While Weissert and Porush combine nonlinearity with the postmodern fragmentation of narrative temporality, among the humanist interpretations it is more common to connect narrative structures to forms that are more obviously spatial, particularly to strange attractors. As Gleick so poetically notes in the epigraph to this section, strange attractors are now recognised as the 'face' of chaos, as the constraints that restrict the ways in which complex systems behave, and his vision of repeated structures on different scales in different phenomena strongly echoes James's organicist view of literature. Among literary scholars, such aspects are combined to produce conceptualisations where the temporality of the literary work is visualised in terms of chaotic geometry, and its autonomy is connected to the idea of emergent, living structures.

Jo Alyson Parker (1997, 2000, 2007) has analysed the temporality of postmodern narratives and she presents the strange attractor as a model that can help us better understand complex narrative structures as 'spatialisation of a temporal process' (Parker 1997: 117). In her article on William Faulkner's *Absalom, Absalom!* Parker (1997) argues that the multiple narratives presented in the novel create a structure in which 'each of the intradiegetic narrators might be considered as beginning from a different set of "initial conditions"', but eventually they all 'fall onto an attractor' that structures the overall narrative (Parker 1997: 110-111). Although her use of chaos theory is mostly well thought-out and her presentation of the combination of form and content intriguing, Parker (1997: 111) confuses the issue by proposing that the strange attractor is an implied central motif, a point that the narrative trajectories approach but never reach: 'All of the trajectories are attracted to, but never pass directly through, what seems

to be the crucial event – the revelation of [Charles] Bon's black blood. We might consider that event as the unstable attracting point, concurrently attracting and repulsing each narrative trajectory'.[38] However, a strange attractor is not a point – that's what makes it so strange. The strange attractor's loops are not themselves attracted to anything, they themselves are the attractor. Behind Parker's description is not anything as simple as a faulty understanding of physics, but a fluctuation in her conceptualisations of structure and theme, and an attempt to see the literary work simultaneously as a narrative process and a structured object. Initially, Parker's argument focuses on the narrative trajectories, presenting both the attractor and the work as dynamic processes where the narrative itself is a strange attractor. But once she begins to describe the crucial but unnarrated event of the 'black blood', however, the attractor is no longer the narration itself, but a void within it, the moment that is not narrated but whose presence can be discerned from the other strands of story. Parker's image of the empty space in the middle of the story that draws on all the different trajectories takes the metaphor 'attractor' to mean a point of attraction (in other words, a single state) and a strange attractor to be a system of trajectories approaching such a point. However, in the first part of the essay the strange attractor was understood to be not a state but a pattern of behaviour.

Many attempts to use the strange attractor as an explanatory tool for literary structure could be similarly criticised for making mistakes in what a strange attractor is and what characteristics it actually has.[39] Although I do not wish to deny that creative analogies have their place in interdisciplinary literary studies, I want to point out these confusions because they reveal the underlying conceptual structures used by Parker and others. The attractor is

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[38] This conception is repeated in Parker (2000: 148): 'Like the trajectory of a Lorenz or butterfly strange attractor, the trajectory of Sterne's text hovers between two powerful but unattainable attracting points – sex and death'; and in Parker (2007: 28): 'In the narrative text, the attracting point comprises motifs that concurrently attract and repel the writer'.

[39] E.g. Gillespie (2003: 56-60), Nemesvari (1997: 17-18).

twisted out of shape because, while making the comparison between literature and phase space diagrams, the scholars are required to switch back and forth between different views of the protean conceptual complex of form and content. Is the literary work an object or a process? Is its meaning a point or a trajectory?

A different approach to that of Parker, yet one that is equally revealing of the author's conceptualisation of literary form, can be found in Joseph M. Conte's impressive *Design and Debris: A Chaotics of Postmodern American Fiction* (2002), one of the few book-length studies on chaos theory and literature that explicitly focus on formal characteristics. What Conte does is combine the spatiality of the strange attractor with an image of the literary work as an organism, particularly in the sense of having the capacity for autonomous growth. Conte concentrates on describing two kinds of American writing which both rebel against the repetition of the formal conventions of any genre – against what he (2002: 76) calls 'writing within the paradigm'. The first group, the 'disruptors', Conte (2002: 29) suggests, include authors such as Paul Auster, Thomas Pynchon and Don DeLillo, whose works 'disdain the readerly conveniences of a linear narrative, with its neat proportionality of cause and effect, which is deemed inadequate to the complexity of the postmodern condition'. Such writing he equates with the order-out-of-chaos paradigm identified by Hayles (1990: 9-10 and passim), and suggests that it relies on the reader's performative choices which make the inherent 'disorderly openness' of the text produce both an emergent structure and its meaning (Conte 2002: 31).

The second branch of American anti-formalism is 'proceduralism', a way of writing that allows the content of the work to arise from the constraints adopted for its form. The proceduralists, like their European counterparts in the Oulipo group, 'formulate a plan comprised of arbitrary and exacting rules, carrying it out in spite of – or in anticipation of – the narrative consequences' (Conte 2002: 27). This group, in which Conte includes Gilbert Sorrentino, Harry Mathews and John Barth, is equated with Hayles's order-within-chaos paradigm because of the as-

sumption that order and structure are inherent to a chaotic system, not created by chaotic processes. The 'content, trajectory, and orderliness' of the proceduralist works are generated by the constraints during the composition, rather than emerging in its reception, as is the case with the disruptors (Conte 2002: 27).[40] The proceduralists, therefore, seem to be relying on a conceptualisation of literature in which the form produces the content but both exist within an autonomous literary work, whereas the disruptors take the view that literature is inherently a process of interpretation where both form and content emerge only in the interaction between the text and the reader.

What is striking about Conte's presentation of the proceduralists is that despite noting their clear commitment to postmodern literary technique, it shows how their underlying philosophy carries strong echoes of Jamesian organicism. Pure formalism is for Conte (2002: 76) 'the equivalent of determinism in the physical sciences', whereas proceduralism 'recognizes an essential uncertainty in the universe of its making'. This uncertainty, however, does not lead the proceduralists to abandon the idea of the literary work as an object that has coherence and meaning of its own. Rather, Conte suggests, the work created by the interplay of essential uncertainty and the constraints set by the author leads to 'synergy' or autonomic growth:

> Synergy in literary design arises when the complex dynamical system initiated by the constraint has the capacity to exceed authorial control. Even though the author is responsible for the *a priori* establishment of the constraint, the unpredictable nature of the language system may result in a creative autonomy, a generative text that far exceeds the enumeration of its preordained structure. In the synergy of the design the text may write itself. (Conte 2002: 84)

'Synergy', understood as the chaotic system's potential for emergent order, is much like James's idea of the autonomous work that is successful – that 'lives' – only to the degree that it manages to be a whole that is larger than the sum of its parts. For Conte,

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[40] Paul A. Harris (1997) also equates Oulipo writing with chaos diagrams.

chaos theory thus provides geometrical forms that point to the conceptualisation of literature as autonomous and alive, while at the same time such forms are able to handle the open-endedness and complexity of the postmodern narrative techniques and avoid the historical baggage of direct reference to the tradition of organicism.

This balance struck between literature as an autonomous object and as a complex process comes out most clearly in the work of Paulson, who in *The Noise of Culture* (1988) explicitly sets out to dissect the organic metaphor but also to show how many aspects of the concept can survive the poststructuralist critique. His volume analyses the concepts through which we think of entities, of their environments and of the way information passes between an entity and its environment. Paulson aims to retain the double influence of the autonomous and the contextualist views, but to do so with a new understanding of what the chaotic interaction of an autonomous system and its context is like. On the basis of Francisco Varela's theories of the structural organisation of living things Paulson (1988: 121) suggests that while literary works are autonomous to the extent that 'as observers we identify the text as a unity', their structure need not be considered a semi-theological mystery. Comparing certain characteristics of literary works to organisms needs no longer be a gesture against analysis, since the dynamic structures of organisms have themselves become analysable. Thus for Paulson (1988: 119) the equation of a literary work with some characteristics of an organism does not mean that its form should be considered as 'synonymous with an ineffable, undefinable organicity', but, on the contrary, by understanding the ways in which it is like an organism allows for a formal analysis that captures both its object-like and process-like characteristics. This re-evaluation of the organic metaphor also allows Paulson to approach the notion of a bounded, yet infinitely variable literary meaning.

Bounded Meaning

Much of the previous work on chaos theory and literature focuses on the notion of text as information. This perspective reveals many interesting aspects of postmodern writing, in particular the way textuality is connected to Claude Shannon's groundbreaking theories of information (see e.g. Paulson 1988, Schachterle 1996 and Terranova 2004).[41] Hayles (1990: 31-60, 236-264) examines the implications of Shannon's theories in chapter 2 of *Chaos Bound*, and in chapter 9 gives a reading of Doris Lessing's *The Golden Notebook*. In the latter she argues that the form of the novel is based on a conceptualisation of information as entropy, and that it therefore highlights the absence of a shared context and the resulting incommunicability of human experience. If the traditional novel is a literary form that represents an individual experience as some kind of a coherent whole, Hayles (1990: 240-241) maintains, the postmodern textuality of *The Golden Notebook* reflects a culture in which such a whole can only be represented by fragmentation and chaos. The postmodern text benefits from the concepts of chaos theory, Hayles suggests, because as an object it manifests the lack of shared meaning in human experience.[42]

A similar emphasis on subjectivity appears in presentations of the process of reading. Gillespie's *The Aesthetics of Chaos* (2003),

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[41] Shannon's (1946-2001) work in information theory and digital computing has been crucial to the development of our current information society. Literary scholars most often refer to his definition of information as separate from meaning, that is, the idea that the amount of information carried by a message actually increases with errors in transmission, although its comprehensibility may decrease.

[42] In *My Mother Was a Computer: Digital Subjects and Literary Texts* (2005) Hayles continues to discuss the ontology of literature and sharpens her focus on the questions of the materiality of literature and the translations that, she argues, inevitably occur when print documents are transferred to an electronic format. In this, as in many of the issues discussed below, Hayles's career shows how questions she maps out through chaos theory in the early 1990s are later on discussed more deeply and without direct reference to chaos theory as such.

to which I referred in section 1.3 as an example of a text which attempts to change the conceptual metaphors that govern critical writing, offers this idea in a fairly radical form. Gillespie uses chaos theory in a series of readings from the Book of Job to *Finnegans Wake* in order to advocate a view of literary interpretations as collages of impressions created differently for every reader and during every reading. While no current theory of interpretation would deny that individual reading experiences vary, Gillespie claims that literary criticism should express the contradictory aspects of reading rather than point to cohesive structures in the work itself. 'The point is', he suggests, that 'my reading resists the linear patterning inherent in the work of the traditional critic', and that 'speaking subjectively is just as valid as perceiving subjectively' (Gillespie 2003: 4, 12). Such a view, I argued, assumes that the critical essay is a detailed reflection rather than a thoughtful distillation of a reading experience, and it purposefully dismisses the idea of a literary work as a structured object.[43]

Many postmodern works yield perfectly to readings that focus on the dissemination of meaning. But where poststructuralist analysis concentrates on presenting the form of narratives as chaotic and meaning as indeterminate, humanist interpretations take strange attractors as symbols which can be used to conceptualise not only coherent narrative structure but also the boundedness of literary meaning. Alexander J. Argyros emphasises the fact that even when the complexity of the individual readings is accepted, chaos theory can justify the use of causality in drawing up the larger structures of narrative which then can be seen as the sources of stable meaning. In *A Blessed Rage for Order* Argyros (1991: 317-319) discusses the structure of traditional narrative in terms of

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[43] Valdés and Guyon (1998: 31-32) present a very different view and argue that there is a fundamental difference between the reading of a poem and, say, creating a critical reading of it. While the construction of meaning during a reading is, they suggest, 'a non-linear process' (in the sense of being dependent on repeated checks backward and intimations forward in the text), hermeneutic criticism, in particular, 'is able to reconstruct the path of bifurcations and place the reading in question in the company of the many other readings that might have been'.

turbulent flow. Adopting the anthropological term of 'causal operator' to describe the 'universal human imperative to explain phenomena by situating them in a causal frame', Argyros (1991: 317) argues that the global, causal form of traditional narrative may encompass many smaller, local narrative structures which can work in many different directions within the larger stream.

> Traditional narratives can be viewed as chaotic laminar systems, rivers characterized by an overall vector, the plot, itself composed of areas of local turbulence, eddies where time is reversed, rapids where it speeds ahead, and pools where it effectively stops. [...] Just as the energy powering the river is supplied by a topographical gradient, narrative tends to function like a dynamical system able to contain a congeries of different temporal relations, each with a specific ability to encode causal information, precisely because of the gradient generated by the temporal asymmetry constitutive of narrative causality. (Argyros 1991: 318)

Thus Argyros (1991: 319) suggests that traditional narrative structures can be both stable and infinitely complex, and that they have both 'recognizable structure' and 'flexibility' because their dynamics are ruled by strange attractors. What unifies them are the causal connections the text suggests to readers in search of meaning. Argyros's point is that traditional narrative can be described in terms of nonlinear dynamics without suggesting that the nonlinearity implies a radical indeterminacy as concerns either the literary work as an object or its meaning to readers.

This humanist perspective on the production of meaning by narrative dynamics has also been applied to non-traditional, excessively reflective narratives. In addition to conceptualising Faulkner's narrative structure in terms of strange attractors, Parker (1997: 99, 117) wishes to 'put forward a heuristic framework for modeling narrative dynamics' which would be 'a means of getting beyond the infinite regress of the poststructuralist theoretical perspective'. While the meaning of a literary work is always multiple and moves dynamically along the attractor's trajectory, Parker (1997: 105) finds that 'out of the plurality of meanings mobilized by its writerly nature emerges the structure of the strange attractor, bounding the text's plural in a zone of meaning'.

This desire to conceptualise variable but bounded rather than absolute literary meaning is a major common denominator in the humanist interpretations of what chaos theory might mean for the analysis of literary structure.[44] Even as humanist scholars rely on the organicist ideal which sees the literary work as an autonomous object, the perspective on dynamics offered by chaos theory makes it possible for them to accommodate the multiplicity of individual interpretations within such an ideal.

William Paulson, whose re-evaluation of organicism depends on blending the notions of autonomous object and contextualised process, also calls for new ways to handle the fact that literature is to an extent autonomous from the ends of its authors and audiences. But in the same breath he argues that this can only be achieved by acknowledging the fact that literature is a human activity that, at least to an extent, relies on communicative processes: 'It will be necessary, in order to describe in a new way the impossibility of treating literary texts as simply messages, to suppose that messages are indeed what they are. In other words, we will often have to treat literature as an instrument of communication in order to prepare a theory of its autonomy' (Paulson 1988: 54). Paulson (1988: 85) thus aims to show, with the help of the concept of self-organisation from noise, how 'literary texts, in spite of everything, manage to signify, how poetry can be valued as an intense, exquisite communication rather than dismissed as poor communication'. A similar attitude lies behind my use of the word 'work' in the title of this section. Even though I do occasionally use 'text' in this study as a synonym to 'a piece of writing', I in fact wish to disassociate that word from the theories of textuality.[45] Thus I support the notion that works of literature are objects which have been crafted by an author and which have a dynamic communicative dimension.

What Paulson does in his 1988 volume as well as later in the article 'For a Cosmopolitical Philology' (2001a) is to combine lit-

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[44] See also Hawkins (1995: 5) and Kundert-Gibbs (1999: 179).

[45] For a more detailed argument for the use of 'work' rather than 'text' see Pettersson (2005).

erature's communicative dimension with the organic metaphor in order to formulate what I would call a humanist theory of literary encounters. Paulson's argument is partly based on Shannon's theories of information, which have been so influential among the poststructuralist approaches to chaos theory, and, as mentioned above, partly on Varela's definitions of biological life as emergent and autonomous. By adding the dimension of intention, Paulson (1988: 135) underlines the fact that literary works are, after all, crafted objects and therefore '*artificially autonomous*'. In other words, their unique way of producing meaning depends on their being treated as autonomous objects, even while they owe their existence to various external networks.

> To those who would investigate it, the literary text implicitly says: 'Consider me an autonomous, natural object. Try to discover my laws of organization, of operation, laws which you must assume to be specified only by what you find within me. To do so, of course, you will have to study the communicative components of which I am made, the signs of language, even though if you assume from the outset that I am a vehicle of communication, you risk missing what is most specific to me. And yet, for all this, my autonomy or organicity is in the end a fiction. I am not a natural object but an artifact, and my meaning is a function of my communicative participation in a larger system'. (Paulson 1988: 140-141)

For Paulson, then, chaos and information theories may dismantle the organicist view so that those elements which he still finds valid (including the coherence of literary meaning) can be retained without losing sight of the valuable contributions of the poststructuralist critique. Paulson's (1988: 120) own conceptualisation of literature in terms of organicity is thus based on both a 'revalorization' and a 'demystification' of the romantic idea: he retains for literature a capacity for meaningfulness over and above other forms of writing, but at the same time argues that the mechanisms on which that capacity is based are part of the universal dynamics of all (physical and cultural) systems. If the natural sciences have found the formal mechanism for the creation of new structures in nature, there is no reason to claim that understanding literature in

terms of life-like properties relies on some kind of vitalistic mysticism (Paulson 1988: 119-130).

Once the organic metaphor is emptied of its mysticism, its reinstatement allows Paulson (2001a: 111-118) to formulate the 'cosmopolitical philology' to which I referred in the previous chapter, a view of literary encounters where the artificially autonomous object is met as 'a delegate of a person'. This is not to say that Paulson commits what Bo Pettersson has called the 'interactional fallacy' (1999: 49), but that he believes the whole enterprise of literature to depend on the reader encountering the work as an object that can put their understanding of how the world is 'at risk' (Paulson 2001a: 113). Thus, despite the fact that Paulson (1988: 137) is ready to accept what he calls 'the most discomforting truths of deconstruction', his thinking draws at least as much on the humanist tradition. While his conceptualisation of literature as 'noise' rather than pure communication assumes that a literary work cannot avoid the 'blind spot of the text to itself' where some undecidability will function as a fracture in the coherence of the work, I take his vision of the literary work to be that of an artificially autonomous, semi-organically coherent object which can engage readers in a dynamic process that has the potential to change and surprise them. This vision Paulson arrives at with the help of chaos theory, which allows him to reconceptualise literary works as organisms in a way that does not involve the extremes of the near-mystical view of literature as an unanalysable entity or the poststructuralist negation of its coherence.

2.2   *Chaotic Geometry in Tom Stoppard's 'Arcadia'*

> A farmer, it is said, hired a team of scientists to advise him on improving his dairy production. [...] After six months' work they prepared their report. The farmer began to read, only to encounter the opening sentence: 'Consider a spherical cow'.
>
> There's an important message behind this hoary tale. The shapes that we see in nature, and the traditional geometric shapes of mathematics, do not always bear much resemblance to one another.
>
> Sometimes they do.
>
> Ian Stewart, *Does God Play Dice?*

Tom Stoppard's play *Arcadia*, like Stewart's 'hoary tale' in the epigraph, contrasts the traditional, Euclidean geometries of spheres, cubes and cones with the infinitely more complex geometrical forms described by chaos theory. The new mathematics may not help us draw a picture of an elephant, as Stoppard's frustrated mathematician says (*A* 47), but it does help to visualise the dynamics of natural systems. Whether it is also a method for picturing the shape of narrative dynamics is a question that may be impossible to answer in terms that would be fully acceptable in the study of literature, but such an idea can be suggested by literary works themselves.

Arcadia is a play about the balance between variety and invariance in human life. It thematises life's unpredictability and uncontrollability, but also the eternal recurrence of sex and death. These themes are folded together with the loss of innocence, the eternal gap between the real and the ideal, and finally, with the question of what exactly counts as beauty for human beings. The interplay of form and disorder is both thematic and structural: the play not only discusses the coherence of human experience in terms of chaos theory, but it also incorporates the structures found in nonlinear mathematics in its very form. The setting of the play, the English parkland that is metaphorically also the classical Arcadia and the Christian Eden, reflects form and content

onto each other by representing two different versions of artistically conceived nature.

The fact that Stoppard uses chaos theory in *Arcadia* is evident in the dialogue, and he has even been cited as acknowledging Gleick's *Chaos* as a source (Nathan 1993/1994: 263),[46] but what has been debated is his motivation in doing so. Simon Jenkins (1993: 16) seems to suggest that Stoppard has simply been attracted to the beauty of fractal surfaces when he states that *Arcadia* is 'the authentic post-modern play, eclectic, picturesque, devoid of morality, glittering with [the director] Trevor Nunn's surface dazzle', and that in it Stoppard 'brushes aside' the question of lost meanings. In a similar vein, Irving Wardle's review in *The Independent on Sunday* (1993: 23) emphasises the play's form over its content in a series of expressions reminiscent of a firework display ('dazzlingly elaborate', 'irregular and unforeseen', 'strikes increasingly brilliant sparks'), and praises Stoppard for finally abandoning any attempt to write about social or ethical issues.[47] While such interpretations forge a connection between Stoppard's work and poststructuralist attitudes to epistemology and ethics by ignoring some of the major thematic elements in *Arcadia*, they do draw attention to the way chaos theory informs the structure of Stoppard's play. What must be added to them, however, is the way that chaos theory functions in *Arcadia* as not just a reflection of complex form and flashy style, but as justification for much more old-fashioned concepts, such as crafted and harmonious form and the value of literary meaning.

Stoppard (as quoted in Melbourne 1998: 563) has stated that his aim as an author of drama is to create a form which may seem

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[46] See also Fleming's (2001: 192-193) study of Stoppard's private papers.

[47] Fleming (2001: 3) notes similar opinions among critics discussing Stoppard's earlier work: 'the postmodern and poststructuralist critics elevate form to the level of content and meaning as they valorize form in and of itself, thereby deprivileging the dialogue as they argue that Stoppard's plays accent the unknowability of the world, the elusiveness of true knowledge, the fallibility of human memory, and the relativity of almost all aspects of life'. However, the earlier plays have also been read as focusing on humanist themes: see e.g. Delaney (1990) and Sammells (2001).

a riot of shifts and breaks in the narrative and in the relationship between the characters and the audience, but which, nevertheless, retains the essential structure of story-telling. What he ideally wants is to 'organize this impossible Rubik's cube, so that it still has the architecture of a – what's the word? – not *conventional*, not *traditional*, but somehow atavistic archetypal architecture of narrative'. In a radio interview in 1970 he also commented that

> the thing which I respond to whole-heartedly is a free mind working within a disciplined form. What I *can't* take is an anarchic mind – not an anarchic spirit, which I admire, but a mind which has no formality to it when it comes to structuring and communicating its thoughts. (Stoppard 1970/1994: 27)

Thus the essential recognition that his own art, and indeed, all art is in some sense disciplined and structured, is a central theme in Stoppard's plays. Furthermore, this commitment to coherent structure does not deter him from utilising the possibilities offered by postmodern literary techniques and structural innovations by which meaning may appear. For example, in *Travesties* (1975) the constant presence of form is emphasised by having Tristan Tzara, in his attempt at portraying total formlessness, end up producing sounds that in another language happen to make perfect sense. As Jim Hunter (2000: 135) has pointed out, the Dadaist poem read out by Tzara at the beginning of Act I:

> Eel ate enormous appeltzara
> key dairy chef's hat he'lllearn ooparah!
> Ill raced alas whispers kill later nut east,
> noon avuncular ill day Clara!

can be understood as a limerick in French:

> Il est un homme s'appelle Tzara
> Qui des richesses a-t-il nonpareil
> Il reste á la Suisse parce que il est un artist
> 'Nous n'avons que l'art' il déclara![48]

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[48] 'The man called Tzara, of unparalleled talents, stays in Switzerland as an artist, declaring that all that matters is Art' (Hunter 2000: 135). Stoppard (1981: 156) has explicitly stated his disagreement with the aims of Dadaism. Of course this limerick, just as everything else in *Travesties* takes place within

Through such linguistic play Stoppard underlines the ubiquitous presence of meaning in all human action. As John William Cooke (1993: 203-204) has noted, in Stoppard's plays even such 'apparent "scraps" of language gain not only meaning, but multiple meanings', and 'nothing expressed through any formal arrangement can fail to signify, to "mean"'.

It is also clear that intertextuality has been a major source of formal invention for Stoppard (see e.g. Levenson 2001). Plays such as *Rosencrantz and Guildenstern Are Dead* (1967/1968) draw not only on Shakespeare's plot, but on the form of Samuel Beckett's *Waiting for Godot*, whereas *Travesties* relies on Oscar Wilde's *The Importance of Being Ernest* for both plot and dramatic structure. Such use of host-texts gives his plays a firm base which functions as an anchor for the multiple points of view presented by the characters. Thus Stoppard sees intertextual borrowing not so much as a universal condition than as a stylistic and formal challenge, as a way out of the Beckett-inspired impasse of 'an ever-narrowing field of vision which has its ultimate in two men locked in a wardrobe' (Stoppard as quoted in Sammells 1988: 19). Even in his first play he solved that impasse by situating the claustrophobic existential arguments of his own two men, Rosencrantz and Guildenstern, within the familiar and richly patterned plot of *Hamlet*, and in both *Arcadia* and its predecessor *Hapgood* (1988) there are not only intertextual references to various literary genres but also to scientific texts.

In *Arcadia* form appears both as dramatic structure and as one of the major themes of the play. The events depicted take place in a single room of an English manor house in two time periods: the early nineteenth century and the late twentieth. In the nineteenth century the daughter of the manor, Thomasina Coverly, is being tutored by a young scholar named Septimus Hodge, and is developing the rudiments of chaos mathematics. Meanwhile the adult population of the manor goes through several rounds of love affairs, challenges to duel and arguments about the

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Henry Carr's idiosyncratic memory and therefore is not a 'real' Dadaist poem even in the world of the play.

nature of beauty. In the twentieth century three scholars, Hannah Jarvis the popular historian, the Byron expert Bernard Nightingale, and Valentine Coverly, mathematician and heir to the manor, attempt in their various ways to discover the truth about the events of the earlier period. The major dramatic tension is centred around two questions: Did Byron kill another poet in a duel in Sidley Park, and who exactly was the hermit who so picturesquely resided in a hut in the middle of the manor's Gothic garden? Bernard rushes to publish his story of Byron's duel, but at the end of the play he leaves in embarrassment when his hypothesis is demolished by Hannah, who finds documentation of the fact that no fatal duel took place. Hannah herself, on the other hand, discovers that the hermit was the tutor Septimus, who withdrew into the garden to mourn the death of Thomasina in a fire, and to try to finish her work on the geometry of nonlinear dynamics. Thematically speaking, interlacing the nineteenth-century arguments over aesthetics with the twentieth-century characters debate on the sciences and the arts creates a play in which the patterns formed in nature and in art are vital to both beauty and meaning.

Classical Geometry and Romantic Freedom

When Stoppard was asked at a conference in the USA to demonstrate how a play germinates in his mind, he used the beginnings of *Arcadia* as an example. The first element, he said, had been neither the plot nor the characters, but 'a passing idea that something could be done with the supposed differences between or conflict between the romantic and the classical' (Stoppard as quoted in Kelly and Demastes 1994: 2). What he did in *Arcadia* was to combine that conflict with chaos theory in order to explore, both on the level of characters and of dramatic structure, the combination of determined form and infinite freedom.

The respective merits of classical and romantic definitions of artistic beauty are present in the dialogue of both sets of characters in *Arcadia*. In the twentieth century, the classically-minded Hannah's projected critical work is on 'the nervous breakdown of

the Romantic Imagination' (*A* 25), and it leads her into several arguments with Bernard, the Byron scholar. Byron himself, whose visit to the manor is one of the main elements in the plot, also functions as a marker for the classical/romantic dichotomy in the play. Naturally, the stereotypical image of Byron fits the role of the dashing adulterer, as required by the plot of Stoppard's play, but as his literary career shows elements of both an eighteenth-century satirist and a brooding romantic hero (Rutherford 1990: xiii), Byron's (off-stage) presence also has a thematic function. The historical person used in the play to anchor it in this particular era and in this particular debate can be regarded as a Janus figure facing both classicism and romanticism.

The interplay between form and freedom is contextualised not only in terms of art history, but also by metaphysics and the history of science. *Arcadia* presents the nineteenth-century debate as arising from the clash between two different views of the universe and its laws: whether determined and consisting of stable forms, or undetermined and changeable. The classical world-view is one dominated by Newton's theories of a deterministic, clockwork universe, and by the artists' renewed interest in the pastoral tradition of ancient Greece. Trust in the stability of the physical properties of the world, coupled with belief in the existence of a perfect state of being, feeds an interest in definitions, rules and formality, which would reveal all things in their perfection. Stoppard's version of romanticism, on the other hand, sets up spontaneity and freedom as the most important ideals that human beings can strive for, and considers man free from the determinism implied by Newton's mechanical universe. Against the classical interest in systems and the will to external control, Stoppard presents a romantic emphasis on the sublimity of the individual and of phenomena that are beyond human control. The same argument is continued in the dialogue between the twentieth-century scholars, with Bernard taking the position of romantic individualism and Valentine that of systematic science.

However, the most elaborate extension of this clash between classicism and romanticism as regards the laws of the universe in

general and artistic representations of them in particular, is the development of the garden of Sidley Park from an Italian geometrical design to a Gothic wilderness. The grounds of the manor function as the field of action for the debate between the neo-classical and the nineteenth-century scientific world-views, as well as classical and romantic aesthetics. Whether following a strictly defined and obvious form or a carefully constructed imitation of irregularity, the garden represents both nature and art, and through it Stoppard explores the continuities between the laws of natural forms and the human need to invest the world with meaning.

In the early eighteenth century, Hannah tells us in *Arcadia,* Sidley Park had a formal garden of a neo-classical geometrical design (*A* 23). This 'Paradise in the age of reason' had a 'topiary, pools and terraces, fountains, an avenue of limes' and 'the best box hedge in Derbyshire' (*A* 27). In the late eighteenth century the fashion changed, and the garden was re-designed by Lancelot 'Capability' Brown, perhaps the most famous landscape gardener in history, who was known for his ability to create a sense of order and harmony without the strict geometrical shapes typical of the parks designed in the French style of the early part of the century. This is the sort of garden which surrounds Sidley Park in 1809, when the play opens. Hannah describes it as 'smooth, undulating, serpentine – [with] open water, clumps of trees, classical boat-house' (*A* 25). This garden is a pastoral dream, constructed to give the inhabitants of the manor a feeling of 'living in God's countryside' (*A* 27). Such imposed order of a landscaped garden is finally rendered ironic by the nineteenth-century Gothic design, which, while as carefully designed as the previous versions, aims to give the impression of the irregularity and freedom that romanticism regarded as the central laws of nature. Lady Croom's indignant reaction to this design serves as a description of what is to transpose the smooth pastoral charm of Capability Brown. Point-

ing at the before-and-after pictures[49] drawn by the new landscape architect she complains:

> Where there is the familiar pastoral refinement of an Englishman's garden, here is an eruption of gloomy forest and towering crag, of ruins where there was never a house, of water dashing against rocks where there was neither spring nor a stone I could not throw the length of a cricket pitch. My hyacinth dell is become a haunt for hobgoblins, my Chinese bridge [...] is usurped by a fallen obelisk overgrown with briars [...]. (*A* 12)

Lady Croom's neo-classical way of looking at nature – her assumption that its orderliness conforms to an idea of perfection defined by God – is contrasted with the new architect Richard Noakes's romantic design, which strives to convey an impression of the drama of the individual's struggle against the overpowering forces of nature. Naturally, the new design follows not only a new vision of natural law, but also one of aesthetic value. As much as Noakes takes it for granted that the jagged, wild and sublime counts as beauty, so Lady Croom finds it completely natural to defend the pastoral garden for exactly the opposite reason:

> The trees are companionably grouped at intervals that show them to advantage. The rill is a serpentine ribbon unwound from the lake peaceably contained by meadows on which the right amount of sheep are tastefully arranged – in short, it is nature as God intended [...]. (*A* 12)

The irony regarding the Gothic garden arises from the dichotomy between the impression of freedom that it is intended to produce, and the immense mental and physical effort that Noakes puts into creating that impression. In Act II, when the conversion is actually under way, the play's action is accompanied by the constant noise created by Noakes's steam pump, working with an ironically 'regular thump' (*A* 81). Lady Croom complains about the condition of the grounds when the transformation is still in

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[49] An idea based on the 'Red Books' of landscape architect Humphrey Repton, which were used for the before-and-after effect in negotiations with his patrons (Barrell 1994: n.p.).

progress, pointing out the fact that nature will not comply to Noakes's designs without considerable use of violence:

> My lake is drained to a ditch for no purpose I can understand, unless it be that snipe and curlew have deserted three counties so that they may be shot in our swamp. What you painted as forest is a mean plantation, your greenery is mud, your waterfall is wet mud, and your mount is an opencast mine for the mud that was lacking in the dell. (*A* 85)

Such dialogue presents to the audience the idea of a garden which, designed to the last ruin and crag, cannot be an expression, but a representation of spontaneity. By these means, Stoppard underlines the difference between organic form and form imposed, between natural forms and works of art, even while presenting them as related conceptualisations that change during the history of human thought.

The lack of originality in the garden designs is another point of irony, suggested by the before-and-after pictures and spelled out by Hannah, the twentieth-century historian. In Act I Noakes's design book is on display as a reminder of his premeditation, a tendency which goes against the ideals of spontaneity and individual freedom of romantic aesthetics. Further, every garden design in the play, including Lady Croom's pastoral version, has been a derivative form of popular art. 'English landscape was invented by gardeners imitating foreign painters who were evoking classical authors', explains Hannah:

> The whole thing was brought home in the luggage from the grand tour. Here look – [she shows Bernard Noakes's book of designs] Capability Brown doing Claude, who was doing Virgil. Arcadia! And here, superimposed by Richard Noakes, untamed nature in the style of Salvator Rosa. (*A* 25)

All three designs for the garden have been created through conscious control and by copying an aesthetic from another art form.[50] Noakes's intention is, like that of the classically-minded designers, to impose a derivative order on a landscape, even

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[50] For the development of nineteenth-century landscape aesthetics see Hussey (1927/1983) and Budge (2001).

though that order is in this case masquerading as natural irregularity.

While I leave the discussion on the accuracy of representation in *Arcadia* to chapter 4, this overview of the debate between classicism and romanticism in the play reveals the extent to which the two world-views dominate the play. Thematically, the debate brings out the positive and negative qualities in both, and shows how elements combined from each attitude can form a view of the world which allows for both structure and individual freedom, for both reality and representation. The solution to the contrast between the determined and the truly free is not made in the play by replacing the classical garden with the romantic version, since both are shown to be equally determined. Instead, it is found in the freedom with which the mind of the daughter of the house moves in its strictly determined surroundings.

Nature's Picassos: Entropy vs. Chaos Theory

In *Arcadia* classical and romantic attitudes towards form are found to be equally lacking, but elements from both are taken up and shown to be combined in chaos theory. Unlike Heinz Antor (1998: 328-329), who equates the elements of chaos theory in the play with 'post-structuralist scepticism', I would argue that the role of such scepticism is played by the concept of entropy, whereas chaos theory is presented as the synthesis of the best parts of classical formalism and the romantic appreciation of disorder. Thomasina Coverly, the precocious daughter of the nineteenth-century house, is a mathematical genius who during the course of the play discovers both entropy and the principles of chaos theory. Each theory breaks open the classical view of the universe, but where the laws of entropy reveal that the universe cannot be a *perpetuum mobile* and is instead moving towards an inevitable stasis, chaos theory shows that such laws can be temporarily and locally inverted by dynamic and unpredictable, but still inherently harmonious systems. In the course of the play Thomasina's discoveries force the classical mind of Septimus Hodge,

her tutor, to face the idea of true freedom and natural variation in a way that the artificial freedom of Noakes's garden could not. Further, the aspects of the organic metaphor that turn out to be the most valuable are found not in the designed and controlled plants and animals of the garden, but in the abstract worlds of art and mathematics.

In Stoppard's play Thomasina's first inkling of the idea of entropy comes with her contemplation of a rice pudding:

> When you stir your rice pudding, Septimus, the spoonful of jam spreads itself round making red trails like the picture of a meteor in my astronomical atlas. But if you stir backward, the jam will not come together again. Indeed, the pudding does not notice and continues to turn pink just as before. Do you think this is odd? (*A* 4-5)

Soon she stumbles upon the same irreversibility in her calculations on the functioning of Noakes's steam engine. Her realisation is that an engine, which produces work from heat, will always need more work to be put into creating the necessary heat than will ever come out of the engine. 'Newton's [gravitational] equations go forwards and backwards', she tells Septimus, 'they do not care which way. But the heat equation cares very much, it goes only one way. That is the reason Mr Noakes's engine cannot give the power to drive Mr Noakes's engine' (*A* 87). More than a century later, Valentine interprets her diagram to Hannah:

> A film of a pendulum, or a ball falling through the air – backwards, it looks the same [...]. But with heat – friction – a ball breaking through a window [...]. You can put back the bits of glass but you can't collect up the heat of the smash. It's gone. (*A* 93)

The implications of this realisation, known as The Second Law of Thermodynamics, seriously undermine the Newtonian clockwork universe. The law shows that instead of ticking on indefinitely in a regulated manner, the universe as a whole will inexorably move towards a state of ever-increasing disorder. The process has been illustrated by the image of dividing a swimming pool, filling one half with water and the other with ink, and then removing the

barrier. The two liquids would eventually form an even mixture through the random movements of molecules. The process is irreversible, and no amount of further stirring would ever produce a state where there would happen to be even a millilitre of pure water in the mixture (Gleick 1987/1998: 257). 'You cannot stir things apart', realises Thomasina (*A* 5).

The implications of entropy have been taken to be twofold. Firstly, the Second Law of Thermodynamics proves that time in the universe can move only in one direction. The heat produced by, for example, steam engines and living beings, inevitably dissipates into the mix. 'And everything is mixing the same way, all the time, irreversibly [...] till there's no time left', Thomasina realises. 'That's what time means' (*A* 94). The second implication of the Law is that as the amount of entropy in the universe can only increase existence will eventually end in a state of complete absence of form, pattern or hierarchy, or, as science writer John Gribbin (2004/2005: 25) puts it: 'all the energy will end up as heat, and all the temperature differences will smooth out to leave a bland and featureless system where nothing interesting happens'.

The concept of entropy has influenced the arts, modernist and postmodernist American literature in particular (e.g. Thomas Pynchon and William Gaddis), where the increase of inert uniformity in the universe is coupled with deep feelings of anxiety (Lewicki 1984). As Thomasina's lines show, entropy is also one of the motifs of *Arcadia*, supporting the play's general themes of order and disorder. However, here entropy does not get the final word, and its effects should not be confused with those of chaos theory. As Stoppard has noted in an interview (Kelly and Demastes 1994: 5), *Arcadia* has a structure which is modelled on the idea of a system which moves from order to chaos: 'in a very crude way the structure of *Arcadia* mimics the reiteration towards chaos [...]. The play bifurcates two or three times and then goes into the last section, which is all mixed up. So, it's very chaos structured'.

The mixed-up effect is created by the increasing speed of the scene changes between the two time periods,[51] until the twentieth-century garden party in Act II scene 5, where the stage is simultaneously occupied by characters from both time periods, oblivious to each other and to the collection of incongruous items from the two periods, which have accumulated on the large table on the stage (*A* 96). At times the characters even handle objects that should belong to the other era, as when the twentieth-century Hannah fills the nineteenth-century Septimus's wine glass and takes a sip (*A* 93). While this development has been noted by many critics (e.g. Fleming 2001: 203-205), it is also important to point out that it does not constitute a descent into entropy, but towards chaos in the sense of nonlinear dynamics. The increase in the seeming disorder of events contains a very clear pattern of alternations between the time periods, and at no point do the narrative or temporal structures of the play entirely collapse. Instead, the nightmarish vision of the entropic universe is counterbalanced by the creative, pattern-making effects of nonlinear dynamics. Even though the time periods on the stage may initially seem to bleed into each other, the characters do not collide with each other or speak to each other across the centuries, and the structure of the alternating time periods effortlessly leads the audience to the complex but ordered experience of the last scene of the play.

Thematically, the same effect is achieved by combining in Thomasina the best of both the classical and the romantic views of order and freedom in the universe. Thomasina's calculations on chaotic form are, first of all, contrasted with Septimus's Newtonian principles. Septimus supports the theories of linear motion in the universe, and dismisses Thomasina's first mathematical discoveries as fancies (*A* 37). He also accepts unquestioningly the precise rules of classical geometry, and calls it, after Hobbes, 'the only science God has been pleased to bestow on mankind' (*A* 84). Thomasina, in contrast, is reaching for a science that would ex-

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[51] See Fleming (2001: 195) for the exact structure of these scene changes.

plain phenomena and forms which are not so sterile as the ones grasped by classical geometry:

> Each week I plot your equations dot for dot, *x*s against *y*s in all manner of algebraical relation, and every week they draw themselves as commonplace geometry, as if the world of forms were nothing but arcs and angles. God's truth, Septimus, if there is an equation for a curve like a bell, there must be an equation for one like a bluebell, and if a bluebell, why not a rose? [...] Mountains are not pyramids and trees not cones. God must love gunnery and architecture if Euclid is his only geometry. (*A* 37, 84)

In her search for a new kind of geometry Thomasina arrives at the first principles of chaos theory, which do admit the existence of an equation for a bluebell, even though that equation might be much too difficult for her to formulate. Her calculations, once pushed through Valentine's computer in the twentieth century, reveal the fractal patterns of nature. 'In an ocean of ashes', Valentine points out, there are 'islands of order' (*A* 76). In a universe that moves irrevocably towards the ultimate heat death of entropy, patterns still spontaneously emerge.

In the dialogue of the twentieth-century characters Stoppard continues to combine the debates over the nature of the universe and of beauty, and reaches out to twentieth-century science and art history to gain more metaphors. While Valentine discards entropy and points out the more optimistic characteristics of chaos theory, he also makes an analogy between the new mathematics and modernist art:

> When your Thomasina was doing maths it had been the same maths for a couple of thousand years. Classical. And for a century after Thomasina. Then maths left the real world behind, just like modern art, really. Nature was classical, maths was suddenly Picassos. But now nature is having the last laugh. The freaky stuff is turning out to be the mathematics of the natural world. (*A* 45)

Thus Stoppard presents chaos theory as the Picasso of mathematics, as the method of creating pictures of dynamics that previously were regarded as much too complex to be mapped in a meaningful way. Therefore, where Antor (1998: 349) takes chaos theory to represent Stoppard's critique of the (sometimes misdirected) 'pat-

tern-building activities' of the characters, I would argue that Stoppard is actually emphasising the pattern-making possibilities in chaos itself. In his article on the chaotic elements in contemporary drama Demastes (1994) describes the difference in the attitudes to pattern in Stoppard and, for example, Ionesco. In absurdist works, Demastes (1994: 251) suggests, there is

> a presentation of existence in the pure chaos-as-randomness phase of human dynamics, decidedly opposed to any causally-informed rationality whatsoever, oblivious [...] of windows of order within the chaos phases of human dynamics.

By contrast, in *Arcadia* the presence of those windows of order, of form in life and art, is underlined. Stoppard's aim has been to give the play shape, and in accordance with chaos theory, that shape has symmetries and reflections which weave a complex, harmonious picture.

The pattern-making abilities of chaotic dynamics are also underlined by the theme of lost and recovered time. One of the major questions presented in the play is whether it is possible to find out the truth about events in the past (see further chapter 4). In a universe ruled by the Second Law of Thermodynamics such a thing is not possible and time only moves in a single direction towards increasing disorder. What Stoppard does in *Arcadia*, however, is to use both self-similarity and temporal loops to create a structure in which time periods alternate and finally coalesce to share the same space.

Furthermore, the play tells a poignant story in which timeless ideas are contrasted with the irreversible death of individuals. The self-similarity of fractals is reflected in the repetitive elements of both dialogue and, as Fleming (2001: 195-196) has noted, in the music, costumes and props specified in Stoppard's stage directions. These echoes connect the two time periods to each other by suggesting that one set of characters self-similarly repeats another. Thomasina's ideas, for instance, were lost to the world until Valentine thinks of them again in the late twentieth century. 'Mathematical discoveries glimpsed and lost to view will have their time again', Septimus predicts. 'You do not suppose, my

lady, that if all of Archimedes had been hiding in the great library of Alexandria, we would be at a loss for a corkscrew?' (*A* 38). However, there is an important difference between the progressive procession of scientific discoveries which are not dependent on a particular individual, and the utterly unique creations of the artistic imagination. Thomasina's romantic sensibility emphasises the uniqueness of works of art and therefore mourns the manuscripts that burned with the library of Alexandria. 'All the lost plays of the Athenians!' she exclaims. 'How can we sleep for grief?' (*A* 38). This difference in artistic and scientific development is also made evident in the arguments between Bernard and Valentine in the twentieth century, and I will return to it in chapter 4. But Thomasina's point about loss being permanent, about creativity being not only about the circulation of ideas but also about personalities, is brought home by her own death in a fire, by her personal genius dissipating in an instant of heat.

One of the odd temporal loops of the play, on the other hand, is Thomasina's jokingly drawn hermit on Noakes's designs for the planned hermitage, which Hannah later takes as the 'only known likeness for the Sidley hermit' (*A* 25). The fact that the drawing took place before the hermitage was built, and thus predates the life of Septimus as the hermit, evokes the possibility that time might circle back to pick up a thread dropped during the previous round. That faint echo is strengthened at the end of the play when Hannah is handed another drawing, this time of Septimus and his tortoise Plautus, a drawing which proves to her that Septimus was indeed the tragic hermit. Such loops in Stoppard's play are suggestive of temporal distortions similar to John Barth's Möbius narratives discussed in the following section, but while they cause momentary disorientation, they do not actually break the causality of the play's story-time.

Ira Nadel (2002: 428) has suggested that Stoppard's temporal loops reflect 'art's attempt to delay the bleak ending established by time moving only in one direction and entropy controlling all'. Certainly, the final coalescence of the temporal iterations in the structure of the play is a re-enactment of the merging of individ-

ual lives to the flow of history and of the inevitable end of both individuals and of the universe itself. However, rather than simply postponing that end, Stoppard's art establishes a bitter-sweet moment where the awareness of inevitable loss is tempered with joy at the creation of pattern and harmony. The final scene of the play is a culmination of the deterministic chaos created by the mix of the two time periods: two couples from different times waltz in the same room to the same music, but both obviously following their own separate orbits in their own separate eras. The simultaneous freedom and harmony Thomasina envisions is symbolised by the equally harmonious though unpredictable patterns of the waltz, a dance which, when compared to the more structured formal dances of the eighteenth century, was initially seen as irregular both in the sense of lacking discernible form and of bringing the opposite sexes to a much closer physical contact than before. In the scenes leading up to the final dance Septimus – who would gladly credit the Germans with the invention of the waltz, as long as the inventor of calculus is acknowledged to be an Englishman (*A* 81) – is again contrasted with Thomasina and her desire for freedom. What Septimus does not initially see is that, just like chaotic dynamics, the waltz has form and harmony, even though that form cannot be pinned down to a simple predictable pattern, and that what Thomasina is actually asking him to do is to help her create their own, unique pattern from the simple, iterative steps of the waltz (*A* 94).

These two main characters from the nineteenth century function as an opposing pair whose debates allow Stoppard to explore attitudes to determinism from both classical and romantic angles, and to combine them in Thomasina's discovery of chaos theory. Septimus's classical mind can initially only fathom two options: either the universe is completely ordered, or everything is disorder and darkness. Thomasina, on the other hand, a romantic mind with a classical education, is able to see that the universe moves according to the unpredictable and unique patterns of turbulence, and therefore has shape and harmony without the strictness of classical forms. In this way, the play explores different sides of the

question as to whether the universe is and should be regarded as determined or free, whether an individual human existence is ordered or random and whether beauty resides in repetition or in surprise. From classical thought Stoppard borrows the importance of structure; and from romanticism he takes the desire for freedom as well as the appreciation of the unpredictable. These aspects he combines in his artistic rendition of chaos theory.

Thus, despite the fact that it was initially praised by theatre critics for its fractured, postmodern structure, the play's chaotic form does not imply the abandonment of textual unity. Instead, chaos is presented as the creator of a fluid form which gives shape, meaning and beauty to the characters' lives. What is more, *Arcadia* is a play in which, as Prapassaree and Jeffrey Kramer (1997: 1) put it, the 'realistic frame holds' despite the 'seemingly surrealistic' moments in the dialogue. For example, even though Septimus's description (*A* 3), in a single breath, of both 'carnal embrace' and Fermat's Last Theorem creates a bizarre moment so typical of Stoppard's plays, the dialogue soon offers a perfectly reasonable explanation for the juxtaposition of those topics in a single speech. I will discuss this realistic frame further in section 4.3, but its presence in Stoppard's play also forms a link to the following section of the current chapter. If *Arcadia* retains a frame that closes the events of the play within a realistic causal structure, John Barth's narratives utilise the technique of frames to emphasise both the craftedness of story-telling and the endless possibilities of artistic reinvention.

2.3 John Barth's Arabesque Frames

> The elaboration of texture invariably has the effect of arresting movement – whether of thought or action – and substituting the opaque for the transparent in language. At its furthest extremes such developments lead to CONCRETE POETRY or Euphuistic Prose involving a progressive elimination of meaning, until a point is reached where the textural devices – dependent as they are on the meaning of words – become ineffective.
>
> Allan Rodway, 'Form' in
> Roger Fowler's *Dictionary of Modern Critical Terms*

Like Stoppard, John Barth is an author who has found in chaos theory the perfect metaphor and structure to express what he has been doing for decades rather than an inspiration for something completely new.[52] His novels, which range from the comparatively brief and in some senses nihilistic *The Floating Opera* (1956/1967) and *The End of the Road* (1958) to the massive cornucopiae *Letters* (1979) and *Tidewater Tales* (1987), all stem from their author's interest in the nature of stories: how they are created; how they change from author to author and reader to reader; and how they live on after their creators. This section focuses on the way Barth uses fractals and strange attractors as symbols for a particular kind of narrative structure. His stories play with both the temporality of narrative and the geometrical form of the literary work, and balance a humanist preference for formal closure with a postmodern desire for open-endedness. His works also seek to combine the readerliness characteristic of the postmodern novel with a more traditional form of literary meaning.

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[52] Words like 'feedback loop' are already in Barth's vocabulary as early as *The Friday Book* (1984: xii). I disagree, however, with Slethaug's (2000: 117) suggestion that Barth is consciously using chaos theory already in the 1987 *Tidewater Tales*. I believe that this novel owes more to his previous interests in the Möbius strip and the Fibonacci spiral than it does to fractals or strange attractors.

In the epigraph above, Allan Rodway suggests that an explicit emphasis on the forms of literature has the double effect of both 'arresting' the movement of the narrative and undermining its meaning. Using a similar point of departure, Alan Lindsay (1995: 106) has argued that Barth's virtuoso use of form 'is nothing more than part of the game', and that his aesthetic is very much part of the poststructuralist paradigm. Thus Lindsay suggests that 'Barth employs form *against* the idea that the relationship between the form of the story and analogous forms outside of the story is inherently meaningful' (Lindsay 1995: 106). However, I would contest Rodway and Lindsay by pointing out how Barth's temporal structures combine the experience of dizzying speed with arresting passages of metafictional digression, and by suggesting that in his works explicitly crafted structure and the relationship of that structure to reality are central to literary meaning. As an example, I focus in particular on Barth's *On With the Story* (1996/1997), in which such notions are explicitly linked to chaos theory.

On With the Story is only Barth's second book of short stories, and like the earlier *Lost in the Funhouse* (1968/1972), it includes both a self-conscious frame tale and a strong thematic unity. Barth himself describes *Lost in the Funhouse* as a 'series' of stories (Barth 1968/1972: 7), and such a description is more apt for both the *Funhouse* and *On With the Story* than either 'collection' or 'volume' of stories, since the books exist in a curious middle state between collected, separate stories and a volume of new stories designed from the start to be read as a whole.[53] Many of the narratives have been published separately before, but the presence of a frame tale, crafted particularly for the publication of each book, creates and reflects a network of meaningful relationships between the shorter pieces. In *On With the Story* the frame consists of

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[53] I follow Suzanne Keen's (2003: 25) definitions of 'volume' (original stories designed to be read as parts of a whole) vs. 'collection' and 'selection' (stories that have been previously published separately). See also Slethaug (2000: 19-20), who connects the separate-yet-part-of-a-whole structure of *On With the Story* to the quantum mechanical wave-particle duality Barth also uses as a metaphor in the series.

a late-middle-aged couple checking in to their tropical 'last resort' (*OS* 4), where their life together seems to end (either by terminal illness or by suicide before they are incapacitated by that illness). In a reversal of Scheherazade's situation, the husband attempts to put off death by reading his wife stories, each in one way or another about love and story-telling, about beginnings, middles and endings, and about the similarities and differences between life and narrative. As such it is a book centrally concerned with the 'laws of narrative', which are already in the epigraphs – the equation for Heisenberg's uncertainty principle and a quotation from Scholes and Kellogg's *The Nature of Narrative* – equated with the laws of physics (*OS* n.p.). One critic has even suggested that 'if Mr. Barth could ascertain [the laws of narrative] more precisely he would happily formulate them in mathematical signs' (Lehmann-Haupt 1996: n.p.). All of these themes are familiar from Barth's previous works, but this time the narrative structure and the terminology used to describe the themes are derived explicitly from chaos theory.

Barth's interest in chaos theory dates at least as far back as 1991, when he took part in a symposium called 'The End of Postmodernism' in Stuttgart. His contributions to the seminar were subsequently published in *Further Fridays* under the joint title '4 ½ Lectures: The Stuttgart Seminars on Postmodernism, Chaos Theory, and the Romantic Arabesque'. Citing both Gleick's ubiquitous *Chaos* and Hayles's *Chaos Bound* as his sources, Barth (1995: 276-348) lays out his vision of what chaos theory might mean to him as a writer. He focuses mainly on the idea of a feedback loop, or what he prefers to call a 'coaxial esemplasy' – a vision of an individual work of art as a reflective and interconnected whole in which major characteristics are repeated on different levels all the way down to linguistic detail. It is easy to see how the narrative structure of *On With the Story* conforms to such a vision, and I will focus on the series as a geometric structure further on in this section. First, however, I would like to draw attention to some of the temporal structures in the individual stories themselves, which also draw on chaos theory.

Chaos and Narrative Time

Even if the analysis of temporal structures were not such a natural starting point in the study of narrative, *On With the Story* plays with time explicitly enough to make such analysis a *sine qua non* for any interpretation of the book. Interestingly, *On With the Story* shares with Stoppard's *Arcadia* not only its clear interest in chaos as a shaping force in art and nature, but also a striking formal similarity in that both works switch back and forth between story-lines that are finally fused together. Where *Arcadia* moves between the two time lines which at the end of the play share the same space on stage, Barth's series alternates between individual stories and sections of the frame tale. The culminating story, 'Countdown: Once Upon a Time' is a collage of events, characters, concepts and metaphors, working itself backwards through all the previous stories until the couple's time runs out at 'T-zero' (*OS* 257).

Barth is well-known for his habit of playing with the temporal structures of his narratives. *Tidewater Tales*, for example, is connected to *Don Quixote* by a suggestion that Miguel de Cervantes's protagonist, while destined to end his life as narrated in the Spanish original, is able to escape into Barth's story through a portal in the cave of Montesinos, and that until he returns into his own narrative he is able to have untold adventures in Barth's novel (see Barth 1987/1997: 521). Another technique appears in *Lost in the Funhouse* where the story called 'Frame Tale' consists of a strip of paper that could, according to printed instructions, be cut out and twisted into a Möbius strip so that the text on its two sides, 'ONCE UPON A TIME THERE' and 'WAS A STORY THAT BEGAN', form a continuous refrain. In *On With the Story* we find both kinds of temporal play connected to certain characteristics of chaotic systems. Time conceptualised as a fractal allows Barth's characters to slip into ever tinier moments in narrative time and extend them by spinning out digressions, while self-similarity and feedback processes are reflected in the idea of time having loops which can return us to earlier moments and be repeated until the narrative is ready to move on.

Both of these techniques depend on the manipulation of the concept of narrative time. Characteristically, in *On With the Story* Barth draws many of his central symbols from the world of writing and story-telling, in particular from the classical narrative arc of beginning, middle and end. The series includes stories which are still only beginning – where the narrators are yet to encounter the 'Dramatic Vehicle' which will move the story forward from its 'Ground Situation' (*OS* 36) – or where they are consciously refusing to leave the middle of the story and use all means available to postpone its end. The conflicting desires for stalling and for acting are also reflected in the title of the collection: 'on with the story' refers both to the desire to speed a story along towards its destination and to the wish that it should never end. The ways in which these narratives stall, stop and speed up again are also techniques by which the narrators attempt to control the passing of time by slowing down their life story, even to the point of changing their life by telling it differently. In chapter 3 I will return to the question of the relation between life and story, which is of course not only a temporal but also an ontological question.

The best example of the principle of fractured time in Barth's series is 'Ad Infinitum: A Short Story', which even in its title presents the paradox of endless time within the limited parameters of ten printed pages. In the story a woman receives bad news over the phone and moves from the house through the garden to tell it to her husband. The brief action required to complete the narrative is extended by asides, digressions, hypotheticals and philosophisings, with the specific aim of delaying the moment when the husband's innocent view of their future is irrevocably altered. The narrative is presented as an ever-fracturing series of moments, as Zeno's paradox in narrative time: 'If our lives are stories', the narrator muses, 'and if this story is three-fourths told, it is not yet four-fifths told; if four-fifths, not yet five-sixths, et cetera, et cetera – and meanwhile, meanwhile it is *as if* all were still well' (*OS* 30). By connecting traditional concepts of story-telling to fractal geometry Barth's narrator envisions literary forms in which endless time resides in a limited, yet infinite, narrative space, and,

conversely, limited real time can be turned into an infinite narrative:

> History is a Mandelbrot set, as infinitely subdivisible as is space in Zeno's paradox. No interval past or future but can be partitioned and sub-partitioned, articulated down through ever finer, self-similar scales like the infinitely indented coastlines of fractal geometry. (*OS* 28)

'Ad Infinitum: A Short Story' also contains one of the more interesting uses of the idea of feedback loops. The husband, in the midst of his gardening, finds himself musing (via recollections of Dante) on a form of punishment in Renaissance Florence, which involved being buried alive upside-down.

> Before that hole is filled, the officiating priest bends down [...] to hear the condemned man's last confession – which, in desperation, the poor wretch no doubt prolongs, perhaps adding fictitious sins to his factual ones in order to postpone the end – and in so doing (it occurs to him now, turning another trowelsworth of soil as his wife approaches from the cherry tree) appending one more real though venial sin, the sin of lying, to the list yet to be confessed. (*OS* 28)

If Zeno's paradox of infinitely divided moments of time postpones the end by slowing down narrative time, the invented sins, which themselves engender an another thing to confess, put off the approaching end by redirecting the narrative back onto itself.

In the title story of the series Barth provides an even more theoretically explicit handling of the relationship between lived time and narrative time and emphasises the contrast between the seeming slowing down of lived time and the speeding up of its narrative equivalent. The story depicts an author sitting on a plane, discussing with a fellow passenger a short story he has written. Barth's narrator digresses repeatedly, 'freeze-framing' the narrative in order to create 'arresting passages' of descriptive or philosophical discourse (*OS* 86). The structure and the setting of the story echo its theme, the one by creating a series of nested narratives that each break off from time to time to digress from the events, the other by depicting the paradoxical speeding limbo of a

passenger plane. The story discussed is printed in the in-flight magazine and is about a woman stuck in traffic, stuck in a life she does not recognise as her own, while her narrative is equally stuck as the narrator in the magazine digresses into the physics of relative motion. But during his digression the nested narrator picks up incredible speed, increasing the movement of his traffic-jammed protagonist with the spin of the earth's axis, the movement of the earth in orbit and that of the solar system in the galaxy, to which all, the author of this embedded story realises during his flight, he should have added the almost imperceptible crawling of continental drift. Thus, rather than accepting the usual interpretation of Zeno's paradox – that the logic of infinitely divisible time means that any actual movement is an illusion – Barth's narrator reverses such a suggestion and makes stillness the illusion:

> All stories are essentially constructs in time, and only incidentally in the linear space of written words. Written or spoken, however, these words are *like* points in space, through which the story-arrow travels in time. Just now it rests at *this* point, this word, this – yet of course never resting there, but ever en route through it to the next, the next, from Beginning through Middle et cetera. Even if and when we linger over an 'arresting passage', we're only apparently at rest in the story's suspended but incessant motion; likewise in our manifold own. (*OS* 94)

Thus Barth plays in a virtuoso fashion with the very same problem of conceptualising narrative time as both a point and a trajectory that critics such as Parker struggle with (see 2.1). Here both aspects are retained by presenting narrative as a temporal process that depends on words being '*like* points in space'. A similar emphasis on a balance between motion and rest, between continuance and closure, can be seen in the story series as a whole. While the temporal effects of the narration draw attention to the endless regression that digressive narration implies, Barth's self-conscious metafictional structures place equal emphasis on the idea of the work of literature as a crafted object. The back-and-forth movement between the individual stories with their repeated themes and tropes, and the frame tale which, again, forms another version of those same themes, creates a self-similar structure so explicit

that it borders on opaque in the sense described by Rodway in the epigraph. However, while such focus on texture is an undeniable part of Barth's fiction, it should be understood in conjunction with the romantic qualities of his writing.

'Chaotic-Arabesque Postmodernism'

The explicitness of Barth's narrative structures has been seen as deliberate opacity by many critics, especially when they discuss his early work (e.g. Gross 1968/1980, Lindsay 1995 and Nas 2000). In addition to temporal loops, the novels and stories are stylistically dense (Barth's characteristic punning is always present) and, with very few exceptions, they contain explicit play with fiction versus non-fiction. Barth's writing is usually metafictional, and in addition to open references, autobiographical hints and intertextuality, one of the most distinct ways he draws attention to the nature of his narratives as fictional constructs are the evident frames built into each book. However, my claim is that for Barth, the presence and the metafictional effects of such explicit forms do not imply a loss of faith in meaning or in the power of literature to represent reality.

Frames (and frame-breaking) have been seen as one of the most wide-spread characteristics of metafiction (Waugh 1984/1985: 28-34, McHale 1987: 197-198). The most common interpretation of the function of frame-breaking has been that it undermines the illusion of realism and causes a domino-effect of relativisations of the levels of reality in a work of fiction. I will discuss Barth's way of using metafictional frame-breaking in relation to his authorial identity in chapter 3. Here I would like to draw attention to the paradoxical robustness of his frames – or perhaps I should say their flexibility. For even when they are punctured or turned inside out, the narrative frames of Barth's stories do not shatter but merely bend in unexpected ways. Indeed, Barth's most frequently used structural symbol, present already in *Lost in the Funhouse*, is the Möbius strip, a surface which

moves from inside out and outside in with no violence or break-age.

The metafictional twists in *On With the Story* also follow the Möbius pattern. For example, 'Stories of Our Lives' narrates the finding of a loose leaf (page numbers 179/180) from a book which is *On With the Story* itself. 'What's going on here?' asks the narratee wife in the frame story and receives the reply: 'Stories-within-stories stories, tails in their own mouths like the snake Ouroboros. Bent back on themselves like time warps' (*OS* 180). Such a blurring of the boundaries between the frame and substance, between a field and its border, Barth (1995: 328-331) suggests in one of his chaos theory essays, is typical of both post-modernism and fractals, as well as the romantic concept of the arabesque – a work of art which includes its own frame, that is, brings the frame inside the work by explicit references to the craft of writing. The frame story of *On With the Story* has just such a function. By providing the context within which the individual stories are told it is outside those stories, but some details within the stories loop to contain the frame, while the loop itself alerts readers to its metafictional qualities.

However, Barth's writings also involve other species of frame, in addition to the malleable fictional/metafictional divide. The frame of *On With the Story* is clearly one that collects the variations and fragmentations Barth creates within the series. Even though most of the stories first appeared independently in periodicals and were only later collected to form a single volume, the frame tale makes explicit the thematic connections between them. Furthermore, the frame is not just a loose overall structure, but aspires to Barth's own ideal of a frame tale that reflects and completes the individual tales. This would be

> a frametale so constructed that the plot of the inmost tale, far from merely bearing upon the plot of the next tale out, actually springs that plot, which in turn springs the next, etc., etc., etc., etc., at the point of concentric climax to which the whole series has systematically been brought. (Barth 1981/1984: 234)

Such an effect can be seen in the final story of the series, 'Countdown: Once Upon a Time', where sections numbered backwards reintroduce the characters and situations from the previous stories.[54] Unlike Slethaug (2000: 21), who suggests that the final section of the series 'leaves the reader uncertain about any ending', I believe that, on the contrary, it produces formal closure, even while it thematically speaks of the 'multiverse' of stories in which other endings may take place (*OS* 251-257). Thus *On With the Story* is a series of stories about beginnings, middles and endings which are given their closure by a final story that, as such, might seem fragmented, but taken as a part of the whole it completes all the others in the series.

Hence, Barth's use of narrative conventions can be considered revolutionary in the sense that he often turns the story inside-out like a Möbius strip, but it must also be noted that his writing has not dispensed with traditional literary conventions in doing so. Where Stoppard's *Arcadia* links chaos theory to the nineteenth-century debates between romanticism and classical formalism, Barth takes Friedrich Schlegel's idea of the romantic arabesque as a forerunner to his own ideas about chaos and postmodern repetition of older conventions. For Barth the interest in frames, however fractured and blurred, reveals an interest in formalism – an interest inherent in both the romantic arabesque and its postmodern progeny, which not so much reject literary forms as become self-conscious and choosy about their use:

> There is a popular misconception of the Romantics as rebelling against all formal constraints in favor of untrammeled freedom (as in their fondness for 'wild' gardens around those 'broken' columns) [...]. But it is clear that in fact [they] have a veritable passion for form – in Wallace Stevens's famous phrasing, [in 'The Idea of Order at Key West'] a 'rage for order' – and that what they're rejecting is only certain *conventions* of order and form. [...] I will venture to say that the principal difference between Romantic

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[54] The precise counterparts of the sections are: 11 – 'Ever After'; 10 – 'Goodbye to the Fruits'; 9 – 'Closing Out the Visit'; 8 – 'Stories of Our Lives'; 7 & 6 – '"Waves" by Amien Richard' and 'Love Explained'; 5,4,3,2 and 1– the frame tale itself.

formalism and Postmodernist romantic formalism is that the latter, more than the former, inclines to the ironic (though impassioned) reorchestration of older conventions – including the classical and the neoclassical – rather than to their rejection in favor of 'new' forms. (Barth 1995: 326-327)

By drawing comparisons between Persian carpets, the frames of arabesque tales, the denaturalisation of narrative in romantic irony, and Mandelbrot sets with their almost-but-not-quite-repeating fractal patterns, Barth (1995: 288-289) defines in the Stuttgart essays his own postmodern aesthetic as 'chaotic-arabesque Postmodernism'. In this conception Barth's (1995: 326-327) original idea of postmodern repetition is 'potentially revalidated – refreshened, reinforced, replenished – by contemporary chaos theory', and he considers it to be his own 'working aesthetic'.

In addition to his interest in romantic formalism, Barth also shares Stoppard's view of the implications of chaos theory in general. In his discussion of Hayles's *Chaos Bound*, Barth, while not dismissing the Prigoginian order-out-of-chaos interpretation, does find a better match for his ideas of romantic formalism in the strange-attractor branch, as Hayles (1990: 9-10 and passim) defines it. The emphasis on fragmentation and discontinuity, Barth believes, is more of a modernist than a postmodernist characteristic, and the location of hidden self-similar patterning in cultural production much better describes the formal aspects of postmodern writing. Further, Barth (1995: 335-341) refers to the theory of self-organised criticality and suggests that its combination of self-organisation with infinite sensitivity to initial conditions is an apt symbol for literary form. Thus, like Stoppard, he is more interested in chaos theory's explanation of the generation and presence of pattern than in its proof of the existence of uncontrollable disorder. Further, as I will argue in the following, the deep interest in formalism and in messages oriented towards themselves does not prevent Barth from creating literary works that nevertheless have a meaning which bootstraps itself beyond self-referentiality.

From Postmodern Irony to Literary Meaning

Stan Fogel and Gordon Slethaug (1990: 215, 217) have commented on Barth's relation to postmodern irony and find that despite the fact that Barth uses many of the techniques of estrangement, his texts do not seek to widen the gap between the story and the reader: 'He is not a remote novelist, one whose deployment of scholarly elements removes him from contact with his readers; rather, the stories are connecting instead of estranging'. This aspect of Barth's use of frames is rarely commented on, but I suggest that there is much to support it. Even a cursory look at Barth's use of chaotic dynamics suggests that it is employed not only as a metaphor for a complex yet coherent literary structure, but also as a way of conceptualising the author's long-standing use of explicit framing as a source of literary meaning.

Story-telling, according to Barth (1984: 167), combines the skill of rearranging formal elements with human passion – algebra and fire, as he calls it, after Borges – and thus, though his literary technique coincides with exhausted postmodernism in repeating established conventional devices and playing with the formal elements of texts, he goes beyond irony by emphasising the passion required to give the story meaning. 'Wait long enough', he writes in *Further Fridays*,

> for the end of art or of the world, and you may be inspired to build a half-ironic monument to mark if not redeem your prolonged attendance. In that monumental labor, moreover, you may well find your irony fired after all with a profound though post-innocent passion; so much so that should Godot in fact arrive, anticlimactically, you would shrug your shoulders and go on with what you're now much more committed to than waiting. Among the opportunities of Postmodernism, for the novelist, is the quixotic revivification – with the right irony to leaven its pathos and the right passion to vitalize the irony – of that noble category of literature: the exhaustive but inexhaustible, exhilarating novel; the long long story that, like life at its best, we wish might never end, yet treasure the more because we know it must.
> But not in a hurry. (Barth 1990/1995: 88)

Barth is thus not only very aware of his own technique of re-invention (see further chapter 3), but also consciously connects it to the modernist *cul-de-sac* of art. Postmodernism, as he has argued ever since the word entered his vocabulary in the mid-1970s (see e.g. Barth 1984: 129), should be understood as the means through which authors are able to keep on writing when faced with the end of art, as the 'half-ironic monuments' they build, even if only to acknowledge that there is nothing much else to do. Such an attitude might be seen as a mark of creative nihilism, but Barth's postmodernism is not about sterile repetition or enforced silence, but about a 'profound though post-innocent passion' which transforms the monuments into something more lively. Robert L. McLaughlin (2004: 58) points out that 'the used-upness [Barth] talks about is akin to the loss of innocence of language or representation's loss of transparency'. But after the loss of innocence one can turn either to detachment or to passion, and Barth, as McLaughlin (2004: 58) realises, has chosen the latter. Even after the medium becomes opaque, the passion still gives his writing meaning. This aspiration is most perfectly manifested in the narratives of sex and story-telling, which Barth often interweaves in his fictions (see further pp. 180-181).

But how is it possible for Barth to conceptualise the reanimated monumentality of impassioned postmodernism? In 1967 Barth (1967/1984: 62-76) published a much-quoted but often misunderstood[55] essay called 'The Literature of Exhaustion', and thirteen years later (1980/1984: 193-206) another entitled 'The Literature of Replenishment'. In these essays he describes the kind of writing which aims at bringing to a completion, or exhausting, a particular convention or style, while at the same time creating something new out of that exhaustion. What Barth suggests is a method of creativity that does not rely on a romantic ideal of genius, or creating something out of nothing, but on a process of repetition and feedback which, if skilfully done, hoists the writing onto a new level.

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[55] Porush (1991: 77), for example, takes Barth to mean that the exhaustion is a cause for the loss of faith in representation.

> The simple burden of my [first] essay was that the forms and modes of art live in human history and are therefore subject to used-upness, at least in the minds of significant numbers of artists in particular times and places: in other words, that artistic conventions are liable to be retired, subverted, transcended, transformed, or even deployed against themselves to generate new and lively work. (Barth 1980/1984: 205)

This combination of exhaustion and replenishment is crucial both to the author's relationship with inherited literary conventions and the structure of an individual work. While his use of established conventions is deeply connected to the question of irony and postmodern repetition, the narrative structure of each of Barth's works in its own way underlines the opacity of language and thus exemplifies the autonomy of the literary object.

Lost in the Funhouse is closely related to Barth's original exhaustion essay and embodies his idea of a literary style or conceptualisation taken to extremes. If its temporal structure is that of a Möbius strip, the central figure in terms of theme is that of a labyrinth of mirrors. Stoicheff (1991: 89-90) notes how the stories thematise the endless reflectivity of fiction and suggests that in this they, firstly, are 'analogous to' fractals and strange attractors, and secondly, form examples of metafictional texts which remain within the circle formed by a created illusion and the deconstruction of that illusion. *Lost in the Funhouse* is, certainly, a good example of how closely Barth's themes and structures resemble the characteristics of chaotic systems, even before he could have become aware of their formulation in mathematics. But more importantly, it is also an example of his aim of exhausting literary conventions and conceptualisations. A labyrinth, he argues in 'The Literature of Exhaustion', is 'a place in which, ideally, all the possibilities of choice (of direction, in this case) are embodied, and – barring special dispensation like Theseus's – must be exhausted before one reaches the heart' (Barth 1967/1984: 75). Stoicheff cites this same passage but crucially excises Barth's comment about Theseus and his 'special dispensation'. What must be remembered about Barth's essay (and about *Lost in the Funhouse*) is that his point is not to confine fiction and metafiction in

the endless labyrinth, or claim that all authors can do is keep repeating the turns within it in a vain attempt to exhaust them and thus gain the centre, but that some authors can make new fictions and new forms from the exhaustibility of the old ones. The centre of a centreless fiction like *Lost in the Funhouse* is the fact that it is a fiction about a centreless labyrinth, a bootstrapped metaconcept which, like Borges's story about Pierre Menard, is able to rise above its own problematics (see further pp. 167-168).

Thus the effect of elaborate structure is not to detach the narrative from meaning but to emphasise the status of the text as a work of art crafted by an author. In this Barth's writing embodies the humanist principles formulated in William Paulson's cosmopolitical philology: a work of literature is an artificial object which, in order for it to be a part of the dynamic process of interpretation, must be treated as if it were autonomous. Similarly, the position envisioned for the reader of Barth's fictions is a combination of narrative revelation and consciousness of the story as representation. Charles Harris (1995, n.p.) importantly recognises the way Barth's insistence on the importance of narrative arises from an emphasis on the centrality of meaning. Barth, he suggests, both 'shares the incredulity toward metanarratives Lyotard identifies as postmodernism's signature' and 'celebrates the narrative urge, which is really the urge to construct meaning'.

This aspect of Barth's writing comes out clearly in *On With the Story* and its references to chaos theory and quantum physics. Here stories gain a status that is simultaneously autonomous and artificial, both metafictionally labyrinthine and meaningful. Thus in 'Ever After' (*OS* 223) the single point of ink that is the story's final full stop opens a dizzying internal space, as well as extends the story's temporal existence beyond what common sense would say is its end:

> Closer, closer, obliging reader: the millions of molecules of printer's ink composing that full stop; the several atoms of carbon in each of those molecules; the furious motion of subatomic particles in any one of those virtually immortal atoms, all but oblivious to time, raging on like so many separate universes [...] to

whatever comparably ephemeral next and next and next and on and on, neither happily nor un-, ever after.

As objects, Barth's stories are endlessly looping trajectories in the finite space of their words. Their meaning is similarly dependent on the double status of words: stories are both semantic and aesthetic, that is, they are 'waves, propagated from mind to mind and heart to heart through the medium of language via these particles called words', which themselves are but temporarily standing waves in the diachronic flow of language (*OS* 143). Thus *On With the Story* embodies Heisenberg's principle turned into a law of narrative. Stories are at the same time points and trajectories, both particles and waves, both objects and processes, and by too much concentration on one aspect you will lose sight of the other.

Therefore the metafictional forms employed by Barth do not serve the purpose of enclosing the fiction in a textual bubble. As Marjorie Worthington (2001: 116) notes about *Lost in the Funhouse*; 'the structural strategies it employs serve also as an attempt to re-center – to reauthorize – the author in twentieth-century fiction'. The virtuoso author is a recurring character in Barth's writing, and even when the narrative is turning in on itself, the recounting of that process of inflection requires 'the emergence of a writer, of a creator' who witnesses and documents that process (Worthington 2001: 129). The analysis of the ways in which chaos theory functions in Barth's fictions shows that his extensive play with texture is not done at the expense of meaning. It also, as Worthington notes, draws attention to the craftedness of narrative and thus to the topic of chapter 3: Barth's conceptualisation of the importance of the author.

Conclusion: Postmodern Romantic Formalists

Connie Willis's comic romance *Bellwether* (1996/1997) is a fine example of how chaos theory's implications for literary form can be handled with a light touch. Willis, better known for her science-fiction novels, has crafted a narrative which draws on chaos theory for its plot, themes and structural metaphors. The novel tells the story of an American multidisciplinary research and development institute, an establishment which is, to the despair of its researchers, devoted to the furthering of management rather than science. Willis's story is narrated in the traditional female first person of romance novels and is interspersed with short paragraphs of encyclopaedic information on American fads. This combination produces a fast-flowing narrative which does not distract the readers' attention from the novel's action and themes. The structure of the narrative also follows a traditional dramatic arc of increasing tension and final release, but Willis explicitly connects this familiar technique to the dynamics of increasing chaos and leap to a new equilibrium. Unlike Stoppard, who in *Arcadia* builds on the mathematics of period doubling towards chaos, Willis uses the physical turbulence of a river as her plot guideline. The turmoil caused by Flip the disastrous office assistant increases from chapter to chapter until a resolution and an equilibrium is reached at the end of the novel.

Similarly to Willis's narrative, which toys with the notion of the traditional novelistic form as a reflection of the turbulence and flow of real rivers, Stoppard's *Arcadia* and Barth's *On With the Story* both reflect in their form the dynamics found in chaotic systems. While they do so in a way that is more ambitious than Willis's, the complexity of these works should not be equated with the breaking of traditional forms for the sake of replacing them with fragmentation. Stoppard's longing for a literary form resembling 'an impossible Rubik's cube' (see p. 105) is much like Barth's conceptualisation of an ideal work as a 'coaxial esemplasy' (see p. 123), and I hope that the arguments presented above demonstrate that both authors' works reveal the respect they have for disci-

plined form. The fact that they have chosen chaos theory to express and shape that form suggests that chaos theory's implications can indeed be connected not only to fragmentation and loss of communicable meaning, but also to dynamic structure and infinitely nuanced but nevertheless largely successful communication of meaning.

While it is obvious that a literary author may draw on the natural sciences in order to spark off his creativity – to 'renew his stock of metaphors' (Barth 2000: 612 with reference to Coleridge) – it is also evident that literary scholars do the same. Thus the non-verbal graphs and calculations of chaos theory have spawned valuable insights into the ontology of the literary work. Information theory and the theory of complexity have been explicitly connected by Paulson to a re-evaluation of the romantic metaphor of the literary work as an autonomous organism. Such a conceptualisation attempts to integrate the seemingly opposing views of the work as an object of interpretation and as the process of interpretation itself. What literature seems to require is an approach that, as Paulson (1988: 121) puts it, cannot settle that question but must, instead, accommodate both perspectives:

> The peculiarity of literature's status in our late romantic era is that while we cannot give up the convention of autonomy – that is, the fact that as observers we identify the text as a unity – we no longer believe that autonomy suffices as an explanation of the text's existence and form. Our understanding no longer coincides with the conventions to which the object we try to understand owes its existence. We cannot get along with or without literary autonomy. As critics and readers, we move from moments when we must treat the literary text as autonomous to moments when we must not.

The movement between the moments of encounter with an autonomous entity and those when literature is seen as dependent on a variety of influences (author, reader, history, ideology, not to mention language itself) is a process that in its complexity defies any real attempt at reduction to anything resembling a method of structural analysis. If chaos theory teaches us literary scholars anything, it is that the study of complex systems involves seeing un-

derlying laws of order within apparent chaos, but also recognising that those laws lead us only to a particular conceptualisation of literature as both object and process. The rigorousness implied by the use of a well-defined formal model may thus turn out to be fool's gold, and more valuable principles of detailed research are found within literary studies themselves.[56] Thus, while chaos theory seems to have played a crucial part in Paulson's and other humanist interpreters' formulations of the kind of object a literary work is and how its form can be described, other scholars have arrived at similar conclusions by other routes. For example, Argyros's (1991: 318, see pp. 98-99) conceptualisation of narrative dynamics as an 'overall vector' which holds within it many smaller 'areas of local turbulence' points in the same direction as the narratological analysis advocated most recently by James Phelan in *Experiencing Fiction* (2007). Phelan (2007: 3) sees form as 'the textual dynamics that govern the movement of narrative' and thus presents the text itself as dynamic rather than monumental, and his descriptions of 'the temporal process of reading and responding' present also the readers' experience of engaging with the text as kinetic. However, he also sees the text as an object in a triangular 'recursive relationship (or feedback loop) among authorial agency, textual phenomena (including intertextual relations), and reader response'. Even while the relationship between the three entities is dynamic, there is also a clear implication that the interaction depends on each of them being in some sense autonomous from the others.

What the comparison between Phelan's approach and the humanist interpretations of chaos theory shows is that the processual notions approached in the 1990s explicitly through the conceptual tools of chaos theory are currently being discussed elsewhere in literary studies. While Parker and Argyros needed strange

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[56] This does not, of course, apply to those approaches that aim to trace crafted mathematical structures in literature (see e.g. Fowler (1970) on numerological criticism of Renaissance literature) or to the analysis of intentionally mechanical literature (see e.g. Conte (2002) on 'proceduralists' and Oulipo).

attractors to conceive of literature in terms that would avoid the Scylla and Charybdis of postmodern fragmentation and mechanically linear narrative (see 2.1), it now seems possible to discuss the literary work as an object *and* a process in terms that stay within the boundaries of the literary discipline. Similarly, Paulson's view of literature as artificially autonomous also finds echoes in current narratology. This kind of thinking is mostly connected to a rhetorical view of literature, currently represented by Phelan as well as Richard Walsh (2007), where the feedback loop between author, text and reader is viewed in pragmatic terms. Furthermore, such scholarship presents the analysis of literary form as a task which no longer restricts itself to the description of the text's internal features, or exists merely in service of interpretation, but as a project that has new relevance to the discipline as a whole, since it suggests that the forms discovered in literature reflect and repeat the forms discovered in cognitive processes more generally. It is also important to note that now that the object/process conceptualisation has been expressed with the help of chaos theory, new research need not necessarily attempt to move further towards chaos theory, but it can also fashion the new view into terms and arguments that are more familiar to the discipline of literary studies.

Barth's reference (see p. 131) to 'Postmodernist romantic formalism' usefully epitomises the many views of literary form presented in this chapter. While the interest in the laws of form remain paramount for both the authors and scholars considered, it is tempered by the desire to regard a work of literature as a uniquely autonomous, semi-organic entity. Added to the mix is a postmodern awareness of the complexity of the relationship between creativity, conventions and meaning – between thought and the already-thought. In the following chapter I move my focus to such issues and consider the ways in which chaos theory can be seen to support a view of coherent human identity in general and John Barth's recognisable authorial identity in particular.

3. Emergent Identities:
Complexity as the Source of Coherence

> Despite the residual attraction of some form of mind-body dualism, I take it as fairly well settled that mind is simply a higher level description of the brain, much as wet is a higher level description of certain molecular structures.
>
> Alexander J. Argyros, *A Blessed Rage for Order*

This chapter will focus on consciousness and identity as phenomena that arise from the feedback process between a self and its images, and on the ways in which such a self can be understood as a coherent entity despite also being in a constant process of emergence. Furthermore, I will argue that chaos theory has acted as a catalyst to the formulation of a humanist view of the self which, intriguingly, draws support from the natural sciences. At least from Descartes onwards the concept of human identity has been threatened by the sciences and their presentation of, first, the human body as a biological machine, and later of consciousness as just one node in a vast network of information. However, more recent writings emphasise the possibility that discarding teleology and emphasising materiality could also, with the help of chaos theory, lead to a humanist view of identity according to which agency and free will are possible. Thus a central theme in this chapter is the humanist search in a postmodern world for room for the self, and in postmodern literature for room for an authorial presence.

William Gibson and Bruce Sterling's novel *The Difference Engine* (1990/1996) depicts the events of a turbulent summer during an alternative nineteenth century, a version of history where computerisation has arrived in step with industrialisation. The calculating machines designed by Charles Babbage have been manufactured, and powered by steam engines, they 'clack' their way through punch cards to conserve and circulate information on the inhabitants of London. The plot of the novel revolves around a

few weeks of rioting in the summer of 1855, when social order in London comes apart, and Lord Byron and his Industrial Radical Party lose control of the populace. A set of main characters is attempting, on the one hand, to manage the social chaos and, on the other, to obtain a computer programme designed by Ada Byron and printed on a set of punch cards. In following the fate of these cards the novel also narrates the appearance of an emergent consciousness within the feedback processes between the programme, the computers and the totalitarian society they were built to monitor. Once Ada's Modus Programme is fed into the computer network it creates self-referential loops of information which finally evolve into a conscious creature.

A central symbol in Gibson and Sterling's novel is an eye looking upon itself, instantiated by the computers that monitor the society which built them. This feedback between the input and the output of the system feeds the emergence of new qualities, and the evolving Modus programme uses the flows of information to bootstrap itself towards consciousness. 'If we envision the entire System of Mathematics as a great Engine for proving theorems', Lady Ada proclaims, 'then we must say, through the agency of the Modus, that such an engine *lives*, and could indeed *prove* its own life, should it develop the capacity to look upon itself' (Gibson and Sterling 1990/1996: 336-337). At the very end of the novel Lady Ada has a vision of a future where not only mathematics, but society itself is a system of information processing that sees individuals only as 'borrowed masks, and lenses for a peering Eye', a system which actually does become self-aware: 'In this City's centre, a *thing* grows, an autocatalytic tree, in almost-life, feeding through the roots of thought on the rich decay of its own shed images, and ramifying, through myriad lightning-branches, up, up, towards the hidden light of vision, [...]. The Eye at last must see itself' (Gibson and Sterling 1990/1996: 382-383).

The cybernetic conceptualisation presented in *The Difference Engine* of consciousness as computation, and of the brain as a computer, has helped scientists to formulate ever more exact models for how the brain functions, but among those who see re-

ductive theories of the mind as a threat to free will this notion has also raised as much alarm as, for example, the advances of evolutionary psychology. Complete success in forming a computational model of consciousness, Porush (1985: 22) writes, would 'provide a powerful philosophical weapon against the notion of free will and a powerful technique for control and manipulation of human activity'. Thus the traditional humanist conceptualisation of consciousness has tended to see the natural science models of the mind as threatening.

However, no purely computational nor physical explanation of consciousness has succeeded in understanding the phenomenon of individual identity. An example of the kinds of problems they run into is the gap between the activity of individual neurons or even between the various areas of the brain on the one hand, and the unity of conscious experience on the other. If the view of a summer shore is processed by my visual cortex, the feel of the wind in the parietal lobes and the sound of the waves in the temporal lobes, how is my conscious awareness of standing on that beach formed as a unified, singular experience?

> [N]eurons span large regions and connect with thousands of other neurons. They are organized into functional maps so that different regions of the brain do different things. Yet the result is a single consciousness. This conflict between integration and segregation is a paradox central to the effort to provide a theoretical understanding of the brain. (Coveney and Highfield 1995: 286-287)

This paradox of a unified consciousness in a functional brain points to a space in which a humanist view may be combined with the latest neurological research. Even if consciousness is a property that arises out of the physical action of the brain, it is not *reducible* to that physical action since it displays properties (the unified experience) that cannot be described or explained by only referring to the action of the constituting neurons.[57]

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[57] From the perspective of the sciences this solution has been presented by the 'Third Culture' (see 1.3). Scholars who concentrate on the question of

The explanatory model that makes such a view possible is that of emergent complexity. Generally viewed as part of the same group of mathematical models as chaos theory, complexity theory aims to explain the behaviour of systems that are more than the sum of their parts, or as Argyros frames it in the epigraph to the present chapter, molecular structures that are best described as 'wet'.[58] According to one definition, emergence involves

> *the study of the behavior of macroscopic collections of such 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 described only at higher levels than those of the individual units. (Coveney and Highfield 1995: 7)

This idea that certain properties of a system can only be described by accepting them as emergent qualities has also been made use of in works of fiction that refer to chaos theory. Connie Willis's *Bellwether* not only models the development of its plot on turbulent flow (see p. 137), but it also presents emergent complexity as being at the heart of many human endeavours. The two main characters of the novel, a cultural historian trying to trace the origins of different fads in American popular culture and a chaos theorist trying to prove that systems develop chaos all on their own, set themselves the task of trying to decipher how information passes in a flock of sheep. The breakthrough in understanding comes when all the different elements of the story – including not only the behaviour of the sheep but also the spread of fads and the inane management strategies of the R&D section – are plotted on a computer and form a graph that explains at a glance the circumstances of both scientific discovery and falling in love.[59] The idea that such diverse phenomena are ruled by the same dynamics, and that the human mind can only perceive those

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consciousness and identity include, for example, Francisco Varela, Daniel C. Dennett and Steven Pinker (Brockman 1995).

[58] Popular accounts of emergent complexity include Casti (1994), Coveney and Highfield (1995), Kauffman (1995) and Lewin (1993).

[59] See Polvinen (2003: 51) and for more details supporting this reading, Aarnio (2008: 184-192).

dynamics when it lets go of the attempt to understand such systems through reduction, is at the heart of the theory of emergent complexity.

In literary studies the idea of emergent complexity and its implications for our understanding of consciousness have been received with some enthusiasm. In particular, many scholars have argued that as a result of the discoveries, the humanities must rethink their understanding of what human identity actually is. '[A]t the very least', Stuart Sim (2002: 93) suggests, 'complexity asks for a reassessment of our concept of personal identity' and, consequently, of all texts that portray, discuss or analyse that concept. However, even if this principle is accepted in literary studies, exactly how the concept of identity should be changed remains unclear. The article in which Sim presents his claim is rather vague as to the actual implications of complexity. It consists of a brief introduction to the main characteristics of emergent complexity and then presents them side by side with some of the recent developments in literary and cultural theories concerning identity (with Laurence Sterne's *Tristram Shandy* as a literary example), but does not specify what the parallels are supposed to show.

In *How We Became Posthuman* (1999) Hayles also takes on the issue of complexity and identity, and does it with much more precision than Sim. Hayles presents the development of the concept of self from the liberal humanist view of identity to the fragmented postmodern subject that exists in the flow of information. While appreciating many of the aspects of the new conceptualisations she also argues for the need to re-engage human identity with individual embodiment and consequently also with what the natural sciences have to say about the embodied brain. In this chapter I follow Hayles in emphasising the need for re-embodying the human, but take up works of literature and literary theory that have appeared since the publication of *Chaos Bound*, as well as point out humanist aspects which, while they are theorised from the point of view of embodiment in *How We Became Posthuman*, are not in that later study connected specifically to chaos theory or to texts that utilise chaos theory as a central theme.

Some authors and critics have also seen in emergent complexity a way of re-thinking the issue of authorial identity by viewing it as simultaneously a singular entity and an interactive process in much the same way as the literary work was seen in chapter 2. Hayles (1990: 115-121) discusses Stanislaw Lem's conception of his own writing as a 'dialectic' between the creative process and the textual object produced by that creation. Hayles regards Lem's movement between the two extremes as a sign of his desire to hold on to the tension between creative chaos and stable order, and argues that Lem thus straddles the divide between the paradigms of rational authority and postmodern play. A similarly protean view of writing as object and process can be seen in John Barth's works, where the author's own literary creativity is in constant dialogue with the works he has already produced, making his entire corpus a reflective whole. One major effect of this view is that it creates an authorial presence that balances the playfully postmodern effects of Barth's semi-autobiographical fictions. The authorial presence emphasises one of the central themes in Barth's fiction (and one that makes his works particularly revealing about the nature of literary identity): the relationship between life and story. Barth's fictions, while playing with postmodern themes and techniques, have their roots deep in a conceptualisation of story-telling as an intentional act of an embodied human being.

As I suggested in section 2.2, one of the central themes of Stoppard's *Arcadia* is the difference between the romantic and the classical world-views, and I would like to make the point that this applies to the characters' temperaments as much as to aesthetics. The differences between Thomasina and Septimus, and between Hannah and Bernard, are most fruitfully viewed in terms of such temperamental differences (see further 4.3). Equally, Septimus's choice not to sleep with Thomasina, and her accidental death during the very same night, are in the play presented in terms of the interwoven powers of fate and free will, or determinism and individual independence. However, as Stoppard (as quoted in Fleming 2001: 194-195) has noted, such differences are not foregrounded

in the play in the same way as the meaning of chaos theory to artistic form and to epistemology are. I therefore refer to *Arcadia* only briefly in this chapter, and take up the characters' identities in the context of the more prominent themes in sections 2.2 and 4.3.

In this chapter I first give a brief overview of how the theory of emergent complexity has been adopted into discussions concerning identity in literary studies. In the second part I concentrate on the works of John Barth and argue that he is a prime example of an author who relies on the humanist view of chaos and identity. I do so not only in order to present an example of a coherent authorial identity but also in order to show that Barth's fiction does what Hayles calls for in her redefinition of the posthuman: provides the representation of emergent human consciousness with a body and with individual embodied experiences.

3.1   The Emergent Self

> The exemplary irrational and 'transcendental' number, pi, represents the ratio between a circle's circumference and its diameter. Mathematicians have calculated its value to some millions of digits and have determined that no repeating pattern exists. So while the circle seems succinctly definable for us, the order of pi remains unintelligible. [...] Is pi an excess produced by the tyrannical rigor of the circle, condemned to meander forever, the irrational creature of a primal repression that founds Euclidean consciousness? [...] Or is the circle just an overrated bubble in the froth of a chaotic universe?
>
> Ira Livingston, *Arrow of Chaos*

In his discussion on narrative and identity Bo Pettersson (2008: 23) describes the etymology of 'identity' as arising from the sense of the Latin *idem* as sameness: "'I have an identity" means in effect something like "I am the same (as me)"', and is thus a rather

vacuous notion that has been given various meanings. The traditional humanist conception of identity takes it to mean that one's view of oneself is actually identical to the reality of what the self is. However, a poststructuralist reading of the notion presents it as an empty tautology and as a symbol of the doubt as to how far our view of anything actually matches, or can be proven to match any originary reality. This has complicated the issue of identity to the extent that rather than being conceived of as definable, enduring or unitary, identity in postmodern culture is often viewed in terms similar to those used by Ira Livingston in his analogy of π and the circle: the coherent shape of the circle, or identity, is presented either as 'tyrannical rigor' that represses the true multiplicity of subject positions, or as an 'overrated' secondary product of the flux of chaotic consciousness. The humanist approach to identity, however, has turned to chaos theory in order to find ways of presenting identity as neither tyranny nor an overrated by-product, but as an enduring natural entity – a standing wave in the flow of consciousness. In the following I will indicate the ways in which such a view can be used to review some of the central problems of both the poststructuralist and the materialist views of consciousness.

Fractal Reflections and Ambiguous Codes

As with the concept of literary form, chaos theory offers some support for the postmodern interpretation of identity. They share an emphasis on reflectivity and a view of life as information or code, which in the case of poststructuralist theory tends to be seen in terms of maximum ambiguity producing maximum value. In *Arrow of Chaos* (1997) Livingston forms a view of identity that is clearly influenced by poststructuralist theory. He combines Foucault's panopticon, Lacan's mirror stage and the emergent patterns found in the schooling behaviour of fish to form a view of identity as 'a school of mirrors' (1997: 27). Here identity is formed by the unceasing mirroring of consciousnesses in a relationship that is reflective, ruled by flocking behaviour and strange attrac-

tors, and lacks a central core. Our way of forming our identities, Livingston (1997: 20) argues, is dependent on abandoning the humanist conceptualisation, and that '[r]econfiguring humanity as posthumanity means recognizing the priority of *betweenness*, of a continuous fractal relation with otherness'. By combining the dynamics of schooling behaviour and the Lacanian approach to identity, Livingston presents chaos theory as a tool with which the reflectedness of identity is fragmented and multiplied and finally dissolved as an entity. In its place Livingston (1997: 11) sets the view of posthuman subjectivity as a dynamic process and presents change rather than identity as the relevant ontological category.

If the universe is thus seen as ruled by a chaotic flux of information, our inability to define the initial conditions of any dynamical process can be understood to mean that the information processing that takes place in consciousness must also be fundamentally fragmented. In his analysis of Carol Shields's *The Stone Diaries* Gordon E. Slethaug (2000: 167-185) suggests that the novel presents both narrative and human identity as such entangled dichotomies. Shields's multiple narrators, Slethaug (2000: 168) argues, 'undermine the value of simple messages and the "wholeness" of societal, auto/biographical, and novelistic conventions, asserting that the subjectification of identity and text is complicated, fragmentary, and implicated'. In terms of Livingston's circle metaphor, Slethaug views Shields's novel as prioritising the excess of fragmentary identity over the circle of the humanist subject. That is, he argues that the novel presents a view of identity and meaning where 'the notion of a transparent, essentialized, centered self or text surrenders to an indeterminate, nonlinear one of opacity, dispersion, gaps, and boundaries' (Slethaug 2000: 170). Once again, the interesting issue is not how far chaos theory actually justifies such a view of either identity or of the novel. Rather, it is much more fruitful to ask why Slethaug would find the use of chaos thematics relevant in his view of identity in Shields's novel. In this particular case, Slethaug considers recent conceptualisations of identity too simplistic, and chaos theory offers him a way of complexifying them.

Most of the theorists and critics engaging with the issue of chaos theory and identity present arguments similar to Slethaug, particularly in emphasising the need for more nuanced ways of conceptualising the interaction between the self and its context. They persist in allowing ambiguity to prevail over whether the self is an entity or a process, whether it has agency or not, and whether the unitary experience of a self is an illusion or a profound truth about the dynamics of the entire universe. Mostly they cultivate this ambiguity quite deliberately, as an expression of a conceptual position too complex to be simply expressed with the vocabulary available to them. This poststructuralist tendency to concentrate on extending ambiguity and multiplicity can be seen in Slethaug's text. By using the duality of chaos theory to describe the main character Daisy's identity in *The Stone Diaries* as 'random *and* patterned, indeterminate *and* determinate, surprising *and* conventional', Slethaug (2000: 185, emphases original), opens up a space between the traditional conceptualisations and through the repetitions extends the time that the new kind of identity can be conceptualised in the minds of his readers. Slethaug (2000: 167-168, 177) repeatedly uses the same rhetorical technique of balancing opposites, while his analysis of the novel concentrates on the fragmentariness of Shields's narrative.[60] Slethaug reconceptualises the self as an ambiguous entity which relies on the deconstruction of all the previous attempts to define it, and despite his rhetoric seeming to balance the opposites of shape and fragmentation, Slethaug finally presents the inconsistency as the originary state which is masked by the patterns presented in the novel. Both the stones and Daisy's diaries, he argues, '*reveal* inconsistency, unpredictability, and indeterminacy *amidst suggestions* of pattern and symmetry' (Slethaug 2000: 178, emphases added). As I suggest in the following, the humanist position, in contrast, presents the pattern and symmetry as real rather than illusionistic, despite the fact that they arise from unpredictable processes.

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[60] On how reflective science writing uses such joint opposites for similar conceptual purposes see p. 59-60 and further Aarnio (2008).

In addition to introducing the idea of an emergent consciousness, Gibson and Sterling's *The Difference Engine* also presents a deeply ambiguous view of that emergent self, and this ambiguity has had interesting effects on the novel's critical reception. While emergence is presented in the narrative as the prerequisite for the creation of a new and more complex autonomous entity, the totalitarian society out of which the new consciousness arises does not resonate with humanist values such as individuality, freedom or creativity. Thus the critical reception of the novel has been divided depending on whether its presentation of society and the materialistic world-view is seen as positive, negative or deftly ambiguous. Herbert Sussman (1994) argues that the novel brings out the joy and excitement in the mechanical developments of the Victorian era. Jay Clayton (2000), on the other hand, explicitly disagrees with Sussman and emphasises how in *The Difference Engine* technology is used to enforce the power of society over the individual in a manner that should be read as critical. Nicholas Spencer (1999), for his part, comes to the conclusion that the novel is deeply ambiguous about this relationship between technology, society and individuality. The 'critical negation' of technology is, Spencer (1999: 426) argues, presented as 'always already' present, but without the possibility of becoming the ruling ideology. By setting the human characters' identities side by side with the development of the emergent artificial intelligence, Spencer (1999: 422-426) suggests, Gibson and Sterling emphasise the idea of a 'technosubject', which simultaneously undermines the traditional humanist self and critiques the inhuman iteratedness of the Modus Eye consciousness. What these diverse opinions reveal is that the evident ambiguity of the novel allows for different readings that emphasise either the positive possibilities inherent in the idea of self as an emergent identity, or the fears that such a view would be scientistic and connected to a society that erases the individuality of its participants. The reason I touch on this debate is that it effectively outlines the contested area of emergent consciousness between humanist, poststructuralist and materialist views of the self. Next I continue to draw that outline by concen-

trating on the major contest between the materialist and the humanist views, that is, the question of determinism and free will.

Determined and/or Self-Determined?

One way of delineating an individual identity is to identify as 'me' those aspects of the world which are in one's control, as opposed to those which constitute the unruly otherness of 'not-me'. For example, in Greg Jenkins's short story 'Strange Attractors' (1999), the protagonist – author of a popular book entitled *Chaos and You* – colludes in his own murder after his trophy wife commits suicide. The story presents the chaotician as a character whose identity to the last is tied to the concept of being in control – including the guilt he shoulders for his wife's sudden action and to the method he chooses for his self-punishment. However, the title of the story refers to fate, which brings together the death-obsessed protagonist and a hitchhiker who admires serial killers. Not wanting to believe in fate as a force external to his will, however, the protagonist sees himself in control of even this chance meeting, telling himself that he had foreseen it (Jenkins 1999: 113). Jenkins's story is an example of the use of chaos theory as a metaphor for the conflict between fate and free will, particularly of a situation where the idea of absolute control and therefore responsibility is preferable to the acceptance of unpredictability in the environment.[61]

The opposite reaction would be to fully embrace the unpredictability of the environment, including – if identity is understood as emerging out of the interactions between different physical and environmental networks – the unpredictability of the future behaviour of the self. Understandably one of the most popular texts used when discussing literary representations of the diffuse subject is Laurence Sterne's *Tristram Shandy*. The novel and its presentation of identity have also been seen in terms of chaos

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[61] For Jean Baudrillard (1994: 110-114) too chaos theory represents the opposite of destiny.

theory, mostly with the aim of arguing that Sterne prefigures the fractured, postmodern identity. Sim (1996), for example, suggests not only that *Tristram Shandy* presents the relationship between determinacy and indeterminacy in terms that are similar to those used by chaos theory, but also that they lead to a dissolution of stable identity and of free will.[62]

However, the universe's combination of determinacy and indeterminacy has also been seen as the source of free will. In Stoppard's *Arcadia* Thomasina envisions a formula according to which the present position of every single atom in the universe would reveal the future. Although the logic of a deterministic universe would seem to agree with this Laplacian[63] ideal, the discovery of chaos showed that such knowledge is an impossibility. The universe is completely determined, but it is still impossible to formulate predictions about its future behaviour. Both Thomasina in the play's nineteenth-century scenes and Chloë in the twentieth-century ones suggest that the reason for this lies in sex: disorder is produced by '[t]he action of bodies in heat' (*A* 83-84) or by 'people fancying people who aren't supposed to be in that part of the plan' (*A* 74). Although the characters are subject to the common behavioural patterns of the physical universe (as is shown by them being in part slaves to their sexual drives), they at the same time manage to be creative, inventive and unique, because the universe's combination of determinism and unpredictability allows free will to operate. As a group, they form a network of individuals whose shared patterns link them intuitively with the thoughts and emotions of other characters, both within their own period and across the centuries, but they are also always free to make their own interpretations of the past (see 4.3). This account of free will within a deterministic universe is made possible by chaos

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[62] Other chaos-influenced interpretations of *Tristram Shandy* can be found in Freeman (2002), Lamb (1990), Parker (2000) and Werner (1999).

[63] Pierre-Simon Laplace, French 18th-century mathematician, whose famous formulation of causal determinism Stoppard borrows for Thomasina. For Laplace, knowledge of the future is limited only by our own computational capabilities.

theory which, as the physicist Roger Highfield (as quoted in Bull 2001: 150) notes in his own review of *Arcadia*, 'rescues free will and chance, giving full rein to the uncertainties of love and sexual attraction that unfold in the play'. Although I would not go as far as saying that Stoppard gives 'full rein' to any uncertainties in his highly crafted drama, Highfield touches upon an important issue in suggesting that, in the play, chaos theory is used to support the marriage of free will and a deterministic universe.

Philosophical arguments concerning free will have mainly concentrated on the question of whether the universe is deterministic and if so, whether freedom can or cannot exist in such a universe. Where libertarian metaphysics denies determinism entirely, those who accept it are further differentiated by whether they find that the deterministic universe is compatible with free will or not. In terms of the present discussion concerning chaos and identity, the arguments around free will may fruitfully be explored by focusing through these philosophical categories on one particular conception of agency. According to Bruce N. Waller (2004), free will is, in addition to whatever transcendent requirements are set, dependent on at least two psychological factors: an 'internal locus of control' and a sense of 'self-efficacy'. The first of these assumes that there is a coherent self that controls the course of its own life, and the second involves the faith that the self has the knowledge required to make rational choices concerning its future. If the universe is posited as completely determined, the individual's internal locus of control is diminished, whereas in a randomly operating universe her sense of self-efficacy would be reduced because there is no possibility of predicting the results of her actions. The question of knowledge is properly the subject of chapter 4, but it is clear that any humanist solution to the problem of determinism and freedom will attempt to define that internal locus of control. What chaos theory can do in this context is to make the internal locus of control, self-determination, thinkable within a determined universe.

The Humanist Posthuman

If the poststructuralist view of identity results in the loss of what humanists would call a self and the materialist, deterministic universe threatens free will, the theory of emergent complexity combines the idea of networks with materialism to suggest that this combination might, after all, support a humanist conceptualisation of the self. Robert Littell's novel *The Visiting Professor* (1993) portrays a situation where an isolated individual learns to immerse himself in feedback without losing his own sense of self in the process. The novel sets its protagonist, a Russian chaos mathematician, in the middle of the hectic events of an American college town with its sex, drugs and serial murders. The novel's themes focus on codes and subtexts, on identity, faith and free will, and on chaos as randomness that exhibits occasional order. The professor's research involves two tasks related to the order of π: firstly, he is attempting to use its endlessly meandering decimal sequence to draft a secret code that would be completely unbreakable. Secondly, in defining ever more decimals to the series he hopes that the continued absence of order within it would prove the existence of God. Real disorder, Littell's professor argues, is not coherently random, but does, by laws of statistics, have some order randomly scattered within it. If, however, the universe could be shown to be truly random it would prove that God exists, since randomness without random order can only be consciously created. But the professor discovers that the world is, indeed, chaotic rather than random, and that the chaos 'conceals in its heart of hearts [...] a simple, elegant, perfectly natural absence of order', not the coherent randomness that would be a sign from God (Littell 1993: 182).[64]

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[64] Aarnio (2008: 214), on the contrary, claims that for the professor, 'finding evidence of pure randomness would prove that the universe is in some sense truly indeterministic, as its inhabitants would then be capable of making choices according to their free will'. I would suggest that in Littell's novel the crucial point is that the protagonist learns to take responsibility for his choices *without* having proof of indeterminism, that is, having faith

Littell also presents the personal life of his professor as a struggle for control which the protagonist predictably loses in the course of the novel. In the end he takes the leap by accepting both the uncertainty of religious faith and the unpredictability of life and love by marrying a woman named by her hippie parents Occasional Rain. 'I can say you [sic] I have become a consenting *homo chaoticus*', the professor admits (Littell 1993: 253). Further, through physical love and slowly developing emotional contact Littell roots his professor not only to the people around him, but also to a physical universe where randomness is not real disorder but chaos, out of which emerge both the possibility (though not the proof) of God and the consciousness of living human beings.

However positive Littell's professor's experience of being a '*homo chaoticus*', the ways in which an individual human consciousness arises from and is dependent on the physical universe can lead to a situation where the individual becomes nothing but a node of connections – a view common to poststructuralist conceptualisations of the self. In emphasising the contextualisation of human existence the chaos approaches to identity may thus open themselves to the incursion of life conceptualised as information, which carries some problems of its own. Unlike Slethaug and Littell, who view the combination of chaos and information theory as a solution to either the simplicity of the traditional concept of identity or to the isolation of self from others, Hayles (1999) presents information theory itself as part of the problem rather than a solution.

In *How We Became Posthuman*, the book that followed the influential *Chaos Bound*, Hayles presents the technological developments and the new conceptualisations of information and cybernetics, as well as examining the ways in which they have affected Western concepts of human identity. In particular, Hayles criticises the way the embodied human being has been sidelined in cybernetics, and how, consequently, individual human identity is uncoupled from individual experience. The development of the

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in his undying soul even when the universe appears to be built on deterministic chaos.

informational conceptualisation of the self, as Hayles presents it, involves both deconstructing the liberal humanist subject and manifesting that deconstruction in cybernetics, which explicitly defines the self through information and computation. For example in the works of William Gibson and Don DeLillo, Hayles (1999: 113) argues, human beings are 'constructed as information-processing systems whose boundaries are determined by the flow of information', and not by the limits of their physical bodies. Hayles criticises these developments because, while she argues with the view that the liberal humanist subject should be deconstructed, she does not wish to tie human subjectivity too closely to the theories of information processing.

In particular, Hayles (1999: 12) traces the problem to two conceptual strategies which she calls 'the Platonic backhand and forehand', both of which present information as the ideal realm of which our embodied existence is just a shadow. The first of these strategies is reduction and general abstraction, traditionally a central tool of Western science. The second involves the concept of emergence and the development of complexity from simple algorithms. The fact that Hayles considers both reduction *and* emergence as dependent upon Platonic ideals means that she does not regard the dichotomy between the liberal humanist subject and the posthuman subject as matching the dichotomy between the circle and the π (that is, definable versus fragmentary), but in terms of disembodied versus embodied:

> Indeed, one could argue that the erasure of embodiment is a feature common to *both* the liberal humanist subject and the cybernetic posthuman. Identified with the rational mind, the liberal subject *possessed* a body but was not usually represented as *being* a body. Only because the body is not identified with the self is it possible to claim for the liberal subject its notorious universality, a claim that depends on erasing markers of bodily difference, including sex, race, and ethnicity. [...] To the extent that [the cybernetic presentation of] the posthuman constructs embodiment as the instantiation of thought/information, it continues the liberal tradition rather than disrupts it. (Hayles 1999: 4-5)

Thus the emergent self, Hayles argues, tends to be presented in cybernetics as a universal human self superimposed unchanged onto various material forms of existence. The final and necessary step, she argues, is taken only when human identity is conceptualised as *dependent* on its body, a step that none of the cybernetic visions has truly taken. Thus what Ira Livingston (1997: 20) calls the posthuman in the context of his Lacanian views, and what Hayles means by the term are two very different things. As the concept of the posthuman is not yet ossified, Hayles hopes to influence its development by deconstructing the liberal humanist self but, rather than conceiving of human existence as a stream of information that can exist in any format, she insists on the importance of embodiment in human experience.

A similarly negative portrayal of the influence of information theory on identity is presented by Patricia Waugh (2005), who not only identifies the 'scriptoral metaphor' which rules both postmodern textuality and contemporary neo-Darwinism (see pp. 65-66), but who also points out how that grand narrative relies on the idea of the flow of information as disembodied and lacking individual experiences. In both postmodern cultural theory and current genetics, Waugh (2005: 262) argues, the body is

> written or inscribed by texts and codes, traces, endlessly replicating, deferred, reiterated and re-inscribed. The text becomes the real. Science and postmodernism seem to share a flight from experience, from the lived body, into an intertextual dematerialization of the real.

Waugh (2005: 227) also convincingly shows how the evolutionary epic blurs the boundary between the physical and the intentional, allowing the natural sciences to formulate a 'theoretically and linguistically heteronomous naturalism' and to take over the spaces previously left for 'the humanistic practices of speculative discourse and art'.

However, it is possible, despite these criticisms, to see emergent complexity as a possible solution to the problem of retaining a space for a humanist identity as well as intentional, embodied experiences (and for literature, which cannot be separated from

either). Complexity theory insists that different levels of reality require different ways of description. Thus the realm of thought and art can be understood as embodied and real without subjecting it to the reductively materialist world-view or the scriptoral metaphor. What I would suggest, therefore, is that by combining Hayles's and Waugh's arguments it is possible to envision a view of a non-reductivist, materially based but emergent human self – a humanist view of the posthuman. Although Hayles sees the concept of emergence as mainly connected to the view of identity as information, there are authors who discuss the combination of emergent identity and embodied experience in much the same way that she calls for in *How We Became Posthuman*. The theories of emergence have been used to rescue some aspects of the self by showing that, as is the case with literary form, it can be a relatively unitary phenomenon despite being entirely dependent on the interaction of multiple processes. Furthermore, by emphasising the need for different levels of description for different levels of reality the humanist presentation of emergent identity includes a more balanced view of the natural sciences than the approaches criticised by Waugh. The self and its experiences are phenomena that are best approached through the methods of the humanities, even though a scientific theory of emergent complexity is used to connect them to the physical phenomena from which they arise.[65]

Argyros (1991: 291-292), for instance, envisions the 'chaotic self' as '[s]imultaneously Cartesian and Heraclitean', and while his view is 'consonant with the intuition of much contemporary theory, that the self is not a fortress carried through time, but a dynamic, changing, multiple, and, at times, contradictory network', Argyros refuses to abandon 'the equally compelling idea that the self does indeed have coherence and integrity'. Building on Douglas Hofstadter's (1979/1994) conception of a chaotic system that 'locks in' on its most stable state, Argyros (1991: 289-290) suggests that the self is a stable, emergent property of the dynamics of the brain. As such, the self not only emerges from the brain,

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[65] Paulson (1991: 49-51) makes a similar point in the context of cognition and different disciplines.

but is also itself a 'dynamical system open to the world and especially to other selves' (Argyros 1991: 291), that is, it is a stable, though evolving phenomenon in communication with its environment.[66]

Peter Francis Mackey's reading of James Joyce's *Ulysses* in *Chaos Theory and James Joyce's Everyman* (1999) uses a similar conceptualisation to discuss the identity of a literary character. Mackey (1999: 128) argues that Bloom's thoughts 'repeatedly emerge as if they were forms or *attractors* within the protean flow of his consciousness. [...] They abide the traits that define his identity, as an eddy abides its shape'. Emphasising the way chaos theory has been used to describe enduring shapes in turbulent water, Mackey (1999: 118-119) suggests that in *Ulysses* Joyce uses water symbolism to point to the same phenomena and link them to Bloom's consciousness:

> Like the complex systems chaos theory studies, Bloom's stream of consciousness changes and moves, yet it also exhibits an underlying form in the consistent qualities of Bloom's personality. He does not merely think about his life and world, he thinks about them in certain ways, revealing the traits that give his identity coherence. [...] His thoughts, in fact, move like a complex system, spinning, turning, folding, almost but never quite repeating a restricted, creative path of personality, akin to how elements in a complex system follow parameters of behavior governed by other pattern-making attractors.[67]

Thus Mackey uses the idea of attractors and stability within turbulence to explain how readers can draw connections and bridge gaps in Joyce's presentation of Bloom's fluctuating thoughts. Thanks to readers learning to recognise the shape of Bloom's consciousness, he remains the touchstone even through the novel's later, more radically disjointed styles. Such recognisability

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[66] For a related view of the emergent self in philosophy and cultural studies see Wheeler (2006). Wheeler's biosemiotics does not, however, refer to the criticism presented by Hayles (1999) and Waugh (2005).

[67] McCarthy (2006: 61-68), like Mackey, conceptualises identity in terms of a standing wave, although he talks of quantum wave functions and not streams of consciousness.

makes Bloom the identifiable Everyman in Joyce's mythical universe: 'This stream of consciousness testifies to the drama that persists even in the commonplace thought, even in the commonplace life. It is the drama that is the evolution of our selves' (Mackey 1999: 144). The stability and the endurance of a recognisable identity make the 'drama' of Joyce's stylistic play and stream-of-consciousness writing possible, Mackey argues, and without it human existence would not be possible.

The central issue in any attempt to rescue aspects of the humanist subject is to resolve the conflict between the interactive view emphasised by postmodern cybernetics and a humanist one that emphasises intention and embodiment. 'If "human essence is freedom from the wills of others"', Hayles (1999: 4), declares, 'the posthuman is "post" not because it is necessarily unfree but because there is no a priori way to identify a self-will that can be clearly distinguished from an other-will'. Emergent complexity, however, is one way of conceptualising a difference between the self-will and those others, because it emphasises the individuality of every end product of a single, dynamic process. In this way the humanist conceptualisation of identity strongly resembles the modified organic metaphor, discussed in the previous chapter, which presents a literary work as simultaneously an object and a process. Similarly, Mackey (1999: 125) argues that the fact that Bloom can be defined as a self distinct from, yet connected to society makes it possible for him to act and to make his identity have an effect on reality: 'Asserting himself, he can *insert* himself too and act upon his overlapping relation to the world'. Thus Mackey presents Joyce's novel as a representation of the chaotic feedback between self and world which allows individuals to be connected to the world beyond themselves.

What is most intriguing about the views presented by Argyros, Mackey and others is the thought that in their search for a non-reductive view of what it is to be human they are turning to the natural sciences. This appeal to science for a ground on which to build a view of human identity is part of a long tradition involving scientific concepts from the heliocentric universe to the

theory of evolution, but I would also suggest that in the context of contemporary literary studies it also stems from the authors' dissatisfaction with the reductive aspects of poststructuralist theory (see further pp. 195-197).

Furthermore, emergence makes it possible to argue that literary tools are naturally suited to deal with (although they do not fully explain) the complexity of human experience and its emergent meanings, and therefore science no longer appears to be as overwhelming a paradigm as it previously did.[68] While it is vital to keep in mind Waugh's warning that the natural sciences should not be adopted as an explanatory model in arts, the humanist view of the posthuman identity tries to extend our understanding by utilising those discoveries of the natural sciences which resonate with its own vision. These authors have identified in chaos theory metaphorical meanings that connect not with the dissolution of the self, but with coherent, though dynamic, identity, and with free will. In other words, agency emerges from the interaction of an embodied individual and his or her environment.

The ways in which chaos theory has been used to deal with the concept of identity have perhaps raised more questions than they have answered. Does the mind create the chaotic dynamics we observe because that is the only way our minds can process things? Or do our minds work according to the laws of chaos theory because that is the way all of the universe (our minds included) functions? If the self is, indeed, a chaotic system, is this a sign of a true correspondence between the self and physical reality or just a reflection of a need to imagine the self as a reflection of dynamics that exist outside it? Rather than attempt to answer such philosophical puzzles directly I will confine myself in the following to the ways in which similar questions arise in a purely literary context, in particular with the issue of authorial identity.

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[68] Appreciation of the special skills of the humanities is evident in, for instance, the recent development of the field of medical humanities, and the increasing number of courses offered to medical students in the techniques of story-telling and interpretation. See e.g. Coles (1989) and Charon and Montello (2002).

3.2   *Authorial Identity: John Barth's Iterated Opera*

> If an idea is worth having once, it is worth having twice.
>
> Tom Stoppard, *Indian Ink*

> [N]o account of who one is can afford to ignore the issue of one's self-interpretation, since the former is (at least partially) constituted by the latter.
>
> Dan Zahavi, 'Self and Other: The Limits of Narrative Understanding'

> [N]ot only is all fiction fiction about fiction, but all fiction about fiction is in fact fiction about life. Some of us understood that all along.
>
> John Barth, 'Tales Within Tales Within Tales'

In her discussion of *The Education of Henry Adams* in *Chaos Bound* Hayles (1990: 61-90) approaches chaos and identity through the relationship between author and narrator/character in autobiographical fiction. The gap between Henry Adams the author and the narrator of *The Education of Henry Adams* establishes both that the author cannot be extrapolated from the narrator, and that there is an autonomous authorial self which 'lingers beyond the reach of textuality' (Hayles 1990: 64). This extra-textual self is structurally equated with chaos in the dynamics of Adams's text, Hayles argues. Order is a realm which becomes present through the act of imagining, whereas chaos rules the physical reality and therefore 'fades into absence' in the text. Similarly, the character of Henry Adams 'materializes into a textual presence because he has been imagined', whereas the author 'fades into absence because he exists in external reality' (Hayles 1990: 77). Hayles's discussion functions as a useful starting point to the analysis of John Barth's authorial identity because I will argue that chaos theory can be used not only to conceptualise an author beyond textuality,

but also to construct an authorial identity that is a tangible presence which nevertheless leaves room for the text itself.

John Barth's narrative re-enactment, both of elements appearing in the work of other authors, and those appearing in his own, is one example of such a construction. Much has already been written (not least by the author himself) about Barth's use of literary predecessors and ancient literary tropes as springboards in his own fiction, but less has been said about his controversial habit, especially since the 1980s, of raiding his own previous works for usable parts. Is a good idea worth having more than once, and iteration a valid aesthetic? I suggest that the concept of iteration provides Barth with a way to deal with his own authorial identity that allows for both growth and continuity. In many of his most recent books Barth explicitly examines the themes of repetition, recycling and authorship. They appear particularly clearly in the 'memoir bottled in a novel' called *Once Upon a Time: A Floating Opera* (1994), on which I will focus in this section. As Barth acknowledges his advancing age and prepares to hand in yet another manuscript, he is occupied by certain recurring questions: How to stop his body of works growing infirm along with his own, aging, physical body? How to go on, when all he seems to do is either repeat himself or quote someone else? How to achieve closure and yet stave off endings? As the speaker of Barth's 'The End: An Introduction' notes:

> For a writer, after all, the alternative 'last-chapter' scenarios are almost equally distressing [...]: Either the end comes before one has had one's entire say (we recall John Keats's fears that he might cease to be before his pen had gleaned his teeming brain) – What an unspeakable pity, so to speak! – or else one goes on being and being *after* one's pen has gleaned et cetera: not so much a pity as simply pathetic. (*OS* 16)

I will argue that as Barth's fictions become more and more focused on the theme of authorship as a career, they also reveal a mature author torn between the 'anxiety of continuance', the fear of running out of things to say before the end of his life (Tobin

1992), and what I call the 'anxiety of completion', the fear of running out of life before his artistic vision has reached its closure.

As a solution to these anxieties Barth has in the last few decades become increasingly occupied with constructing an authorial identity through self-referential intertextuality. This identity is focused through a character who is the author's personified narrative imagination, and who provides him with both continued inspiration and a frame which explicitly draws his works into a coherent whole.[69] As Dan Zahavi notes in the second epigraph above, self-interpretation is crucial to any identity, and I believe it is explicitly present in the way Barth's constant re-interpretation of his own works shape his authorship, just as observing 'its own shed images' shapes the emergent consciousness in Gibson and Sterling's *The Difference Engine*. Furthermore, Barth is a writer whose frame-tales have often ended up subsuming individual narratives, making novels out of his planned collections of short stories (Barth 1995: 103), and I believe that his self-interpretations reveal a meta-frame in the making.

The final epigraph to this section comes from Barth himself and acts as an introduction to the ways in which Barth's authorial identity connects to the concept of personal identity in general. When one of the best-known authors of postmodern metafiction in America states that 'fiction about fiction is in fact fiction about life', anyone interested in the intersection of narrative and identity should sit up and take note. Fictions produced by the human imagination, Barth is saying, are finally about how human beings experience their lives, and a central element of that experience is the way we tell stories about ourselves. An additional level to Barth's comment comes from the way he incorporates theories of emergent consciousness in his fictions in order to present writing as a self-replicating or reproductive urge, as a way of living more lives than biologically possible. For Barth story-telling, like life, in-

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[69] In terms created by Wayne C. Booth (1979: 268-275) this identity might be called a 'career author', but one constructed by the author rather than the critic.

volves complex pleasures that draw their power from our experiences as embodied human beings.

Intertextuality: Recycling Literary Predecessors

As I argued in section 2.3, Barth's conception of the 'literature of exhaustion' has more to do with being able to create novelty out of worn-out conventions than with merely announcing that those conventions are, indeed, worn out. The difference between Barth's view and the theory of the anxiety of influence (which it was seen by some critics to represent) is that Barth as an author is not at the mercy of the textual past and his predecessors, but is, instead, an individual who is able to engage in dialogue with them. Patricia Tobin, for example, (1992: 7-9) suggests that Barth's way of dealing with the anxiety of influence is to interact with the great-grandfathers such as Homer, Cervantes or the anonymous author(s) of *The Thousand Nights and a Night* rather than his immediate and thus more imposing predecessors. This is true in the sense that the explicit intertextual references in Barth's fictions are made to such faraway ancestors. However, as he states in many essays, his writing (particularly in its formal elements) is created in dialogue with, for example, the works of Borges, Italo Calvino and Gabriel Garcia Márquez. Thus, even though Barth may avoid naming his immediate predecessors as conversational partners in his fictions, he is perfectly willing to acknowledge their influence. 'My ideal postmodernist author', Barth (1980/1984: 203) writes, 'neither merely repudiates nor merely imitates either his twentieth-century parents or his nineteenth-century premodernist grandparents. He has the first half of our century under his belt, but not on his back.'

Central to the ability not to be overwhelmed by the literary past is Barth's way of maintaining a balance between the aesthetics of novelty and of repetition. In 'Innovation and Repetition: Between Modern and Post-Modern Aesthetics', Umberto Eco (1985) differentiates between various attitudes towards repetition in classical, romantic, modern and postmodern aesthetics. If the

classical era respected the creation of a perfect example of a type and the romantics envisioned art as the creation of something out of nothing, a major characteristic of a modern aesthetics is the creation of novelty out of known elements. Such an aesthetic, Eco (1985: 173-174) argues, depends on two characteristics: on the one hand the work presents 'a dialectic between order and novelty', and on the other the audience must be able to perceive that dialectic. But where the modern conception seeks such a balance between scheme and variation, the postmodern view focuses on the fact of variability itself.

> Variability to infinity has all the characteristics of repetition, and very little of innovation. But it is the 'infinity' of the process that gives a new sense to the device of variation. What must be enjoyed – suggests the post-modern aesthetics – is the fact that a series of possible variations is potentially infinite. (Eco 1985: 179)

The fractal narrative techniques discussed in section 2.3 reveal how important Eco's postmodern principle of infinite variation is to Barth's conception of literary form. At the same time, Barth goes even further than Eco's definition of postmodernism in the sense of acknowledging, but not stopping at the fact of infinite variation. Writing about Borges's short story 'Pierre Menard, Author of Don Quixote' in 'The Literature of Exhaustion', Barth (1967/1984: 69-70) is perfectly ready to recognise Borges's originality, but rather than identifying genius as the ability to create something enjoyable in spite of the fact that so much has already been said, he portrays it as the ability to recognise an unsolvable dead-end and create innovation *out of* that recognition. 'Borges *doesn't* attribute the *Quixote* to himself', Barth (1967/1984: 69) points out, 'much less recompose it like Pierre Menard; instead, he writes a remarkable and original work of literature, the implicit theme of which is the difficulty, perhaps the unnecessity, of writing original works of literature'. Barth is thus suggesting that Borges's narrative, while it tells a story about the difficulty of originality, manages to be strikingly original, and that although Pierre Menard's quintessentially postmodern gesture merely points at the infinite variety of contexts, the method of recontextualising old

stories and techniques can be of value when it is reflected back on itself by Borges; an old story is recycled in an original story about the recycling of stories.

Thus the solution Barth (1980/1984: 205) offers to the problem of literary 'used-upness' is one of impassioned recycling, or repetition with imagination and intent. John Barth may be a Johnnie-come-lately, writing in the shadow of thousands of years of human literary creativity, but rather than seeing literary history as an oppressive force, he uses it as a source of inspiration. Barth's favourite visual symbol for this process is the Fibonacci spiral formed by the chambered nautilus, a structure which allows both repetition and growth:

> The spiral reenacts the circle, but opens out [...]. The nautilus' latest chamber echoes its predecessors, but does not merely repeat them, and it is where the animal lives; he carries his history on his back, but as a matter of natural-historical fact, that history is his Personal Flotation Device, not a dead weight carrying him under. (Barth 1984: 170)

In his essays Barth tends to present his own ideal of a postmodern artist as the natural and fairly uncomplicated solution to the problem of exhaustion. It is clear from his fictions, however, that practicing what he preaches is not quite as straightforward. Though the notion of an inexhaustible, re-inventing, passionate postmodernist is argued clearly in his non-fiction, his fiction seems less certain of how to reach that ideal.

One representation of the danger of uninspired imitation appears as early as *Chimera* (1972/1991). Of the three novellas in this collection, all of which present different methods of using the past for continued inspiration, 'Bellerophoniad' depicts the risk involved in using imitation as a method of gaining a place in the pantheon (or canon). It tells the story of Bellerophon, who imitates the careers of mythic heroes in order to become one himself, but only manages to become an imitation of a mythic hero. A more optimistic view, this time of an author bootstrapping him-

self to originality,[70] appears in *Tidewater Tales*, where the exhausted postmodern novel is replenished by the long tradition of oral story-telling. The blocked author Peter Sagamore (the name reflects the storyline: though his voice seems to be petering out, he ends up being the teller of a cornucopia of stories) is looking for a release from his self-conscious and reductive style of writing, where, 'as more and more goes without saying, less and less gets said' (Barth 1987/1997: 405). His solution to the blockage is an example of recycling the works of others: when sailing with his pregnant wife Peter listens and makes notes on dozens of stories told by the people they meet; stories which finally, along with the frame story of their cruise, culminate in his unblocking and in the birth of their twins.

As Fogel and Slethaug (1990: 202) have argued, *The Tidewater Tales* is an explicit exploration of the idea that 'stories are not divinely intuited by one author, but are the carefully constructed product of current and historical linguistic, literary, and cultural experiences. Writing and narrating become collective concerns that involve scores of people, both contemporary and ancient'. At the same time, the novel is a celebration of the individual talent story-tellers have in fashioning their narratives into original wholes, despite the fact that they are working with elements that have passed through many hands before them. Relating Barth's thinking to that of Roland Barthes, for example, shows that where Barthes (1968/1988: 170) replaces the author with 'the scriptor', who 'no longer bears within him passions, humours, feelings, impressions, but rather this immense dictionary from which he draws a writing that can know no halt', Barth's (1990/1995: 88) fictions are creations of a thinking and feeling intellect, and fuelled by a 'profound though post-innocent passion' for the power of story-telling.

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[70] The author as a mythical hero is a common motif in Barth's fiction both before and after he familiarised himself with Joseph Campbell's description of the life cycle of the wandering hero (see *OUT* 114-121, 313-317).

Autotextuality: Barth Recycling Barth

Chimera, while it tells a cautionary tale of Bellerophon, also includes the story 'Perseid', which suggests that the most fruitful solution to blocked creativity might not be imitation of others, but of yourself. It recounts the fate of Perseus, who, having lost his way in middle age, successfully reorients himself by retracing and re-telling the story of his own heroism. As I argued in section 2.3, Barth presents re-enactment as a narrative device through which the story loops back onto itself and thus manages to contain an infinite number of stories within the finite space of a single book. It should, however, also be noted that Barth's entire body of work is built on an evolving autotextual structure of repeated and reflective elements.[71] Barth (1998: 664) has admitted to his (initially unconscious) habit of writing books in pairs, but as his corpus has grown it has also revealed more complex and wide-spread patterns of repetition. For example, from the 1982 novel *Sabbatical* onwards, nearly all of Barth's books have featured the central motif of sailing, mostly around Chesapeake Bay on the east coast of the United States. Showboats make frequent appearances, as do first-person-plural narrators (usually man and wife), Scheherazade and (especially in the 1980s) the CIA. Equally pervasive is the use of the phrases 'once upon a time', 'it goes without saying' and 'on with the story'. Tobin (1992: 9-10) makes the point that, viewed through the 'Bloomian schema of oedipal conflict', Barth is confronted with an 'anxiety of continuance' where the anxiety defined by Bloom as an external influence on authors is an internal anxiety for Barth. His struggles with his own previous writerly selves are realised in his works as the reiteration and continuing development of tropes, themes and narrative structures from previous publications. Barth solves these struggles, Tobin (1992: 10) sug-

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[71] 'Autotextuality' in the sense of intertextual relationships between different works by a single author is usually attributed to Lucien Dällenbach (see e.g. Andrews 1999). Chollier (2001: 4), on the other hand, takes it to refer to 'vocal exchange within a given novel'.

gests, by reinventing himself in each new work, by setting himself 'as new ephebe to his own precursor, in order that the career might go on'. Thus the iterations function as generators of new material, enabling Barth to take elements from an already published book and to extend their meanings by rewriting them in a different context. Self-repetition, as well as the repetition of illustrious predecessors, thus becomes a solution to postmodern exhaustion. Whereas Barth's use of repetition in narrative structure is governed mostly by the idea of fractal infinity and feedback loops, the reiteration of narrative elements from work to work has more to do with the concept of emergent complexity. The repetitions create links between the works and make the oeuvre into an organic whole in which the interaction of the repeated elements generate meanings that go beyond those contained within the individual works.

Therefore the reiterations not only enable Barth to extend the life of his body of works, but they also unify that corpus into something like a single entity. By creating a network of resemblances and repetitions between his fictions, Barth emphasises the single creative effort behind them: the narrative imagination that has spawned each work. This coherent narrative imagination has also appeared as a reflective autobiographical character in Barth's books.[72] Already in the epistolary novel *Letters* (1979/1980), the correspondence is conducted between 'Mr John Barth, Esq., Author' and various fictional characters who have appeared in his previous novels and stories. In his later works Barth has made fictionalised autobiography an increasingly central element, turning the whole concept of authorship into a literary theme which focuses on the relationship between life and story. In this section I focus on Barth's fictional memoir *Once Upon a Time: A Floating Opera* (1994), which not only explicitly thematises his authorial iden-

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[72] For a discussion of authors appearing as fictional characters see Franssen and Hoenselaars (1999). Many of the elements they identify in the genre of 'author as character' also apply to Barth's fictional selves, e.g. questions of intertextuality, creativity and reference. Their collection does not, however, discuss the question of authorial identity at any length.

tity, but also presents that identity in terms Barth found in chaos theory.[73] If Barth's idea of the 'coaxial esemplasy' is, first of all, the principle through which a work of art forms a reflective whole (see 2.3), in this book Barth uses the same concept to describe the creative process in addition to the structure of the product.

The building of the authorial persona out of the complex combination of experience and narration is presented in this memoir through one of Barth's repeated images: that of 'finding oneself at sea'.[74] In *Once Upon a Time* the narrator, a middle-aged author of postmodern American novels, sets out on a late-autumn sailing cruise with his wife in the hope of rekindling his inspiration. They are caught in a storm and thrown off course, finding themselves in a labyrinth of marshy tidewater coastland. The narrator sets off in a dinghy to seek a safe route out, and the opera relates the process of him finding his way back aboard his craft – both in the sense of his sailboat and his writing skill. The frame of the memoir is explicitly fictional, but during his wandering in the marshes the narrator reviews his life, which, while not quite the autobiography of John Barth, is 'a kind of ship's log of the Inside Passage, framed by this fictitious literal voyage' (*OUT* 384).

While the resemblances between his life and his stories are fairly self-evident in all of his works, in *Once Upon a Time* Barth explicitly sets out to write a memoir which mixes fiction and non-fiction. In the 'Programme Note' which opens *Once Upon a Time* Barth (*OUT* n.p.) writes:

> *Once Upon a Time* – a memoir bottled in a novel and here floated off to whom it may concern – is not the story of my life, but it is most certainly *a* story thereof. Its theme is Vocation. The better to sing it, I have passed over or scarcely sounded other themes,

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[73] For a discussion of autobiography as a theme in Barth's earlier works, see Martin (2003).

[74] Barth has made most mileage out of the paradox in this phrase in *The Last Voyage of Somebody the Sailor* (1991/1992), where the protagonist, lost in the world of Sinbad the Sailor, finds his way by redefining his identity through narration. The novel's themes are very similar to *Once Upon a Time*, but it appeared before Barth became consciously aware of chaos theory as a possible metaphor for the reflective loop of self-definition.

and have reorchestrated freely to my purpose. Of my children, for example, as of real friends and colleagues past and current, there is scarcely a mention. My twin sister makes a fictionalized cameo appearance. My ship- and lifemate, this opera's dedicatee, takes a larger role, likewise fictionalized, in its opening and closing scenes. My thanks to both for their permission to be thus imagined. I have been careful of all hands' privacy except my own, and even that has scarcely been trespassed on. Every life has a Scheherazadesworth of stories.

Such conscious declarations do not alter the fact that Barth's fictions in general and this memoir in particular present their readers with a narrator and/or focalising character who obviously shares many of the author's life experiences, and therefore cannot be defined as purely fictional, at least not in the conventional sense.[75] Borrowing terms from Gérard Genette (1997), we could perhaps say that Barth is treating his own life as a hypotext, and his writings relate his life through the various kinds of transpositions Genette describes as taking place in intertextual relations. But whereas in literary hypertextuality the reader can make direct comparisons with the text and the hypotext, Barth's works simultaneously tempt and forbid readers to extrapolate the author's life from the fictionalised versions of it. His novels make it clear that fiction and narration are not necessarily the same thing, even though both are forms of story-telling, and in some sense this resembles Roland Barthes's (1979: 77) description of a text's relationship with its intertexts: the reading of a text cannot be a process of 'filiation' or connection to 'sources' and 'influences'. However, if Barthes, perhaps provocatively, goes as far as seeing the author's life as being 'no longer the origin of his fables', Barth retains the connection between life and story, even though a multitude of stories can be told about a single life. A story of his life is not his life, but it is still 'a story thereof'.

In order to keep the reader at an arm's length and discourage simplistic biographical readings, Barth has created for his memoir

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[75] For a discussion of similar elements in the autobiographical fiction of Richard Brautigan and of the relationship of postmodern American fiction to referentiality see Pettersson (2004).

a temporal structure that is deliberately confusing and forces the reader to be constantly aware of the fictionality of its frame tale, however factual the details of the life story narrated within it. The narrator of the frame tale is telling his story in 1990 about events which supposedly happened in 1992, and his tale is peppered with footnotes by 'the Author', who is writing the book in 1991-1992. Such a temporal structure resembles the narrative loops Barth constructs in *On With the Story*, published just two years after *Once Upon a Time*. In the latter, the story of the narrator's life is told within the frame of the sailing trip, but eventually it reaches and passes the time when the frame tale itself was told. The narrator explains that his decision to 'set the action of this narrative not in "real" time but in an imagined near future that the present will presently overtake' was motivated by the desire to set this story apart from reality, as 'a voyage out of the time of its imagining and writing into the time imagined and written' (*OUT* 127).

Further fantastic elements in the frame tale include a Virgil-character the narrator meets in the marshes. Variously called Jerry Schreiber or Jay Scribner (Barth's tongue-in-cheek reference to John the Scribe), this guide is the authorial persona's fictional friend and alter ego. Jay/Jerry gives the narrator a Parker fountain pen which functions as a time machine, first taking the narrator's imagination back to his childhood and then producing a story of his life: 'Time's arrow on the butted cap points pointward, to where the ongoing present's nib resistlessly pasts the future, eluci-dating all three' (*OUT* 364). Barth's memoir could thus also be seen as a self-conscious play on autobiographical reference, such as Paul John Eakin's (1989: xiii) notion that 'the true reference of *story* in autobiography is not to some comparatively remote period in the subject's past but rather to the unfolding in language of the autobiographical act itself'. This self-referential spiral is symbol-ised in Barth's memoir by the Parker pen which makes it possible for the story of his life to emerge in the act of its imagining. Hence, the reference of Barth's narrative is not to the life the au-thor has lived, but to the writing of that life.

By creating a feedback loop in which he imaginatively relates the story of his life, Barth shows how the narration of the (or a) story of the author's own life can reanimate his literary imagination. The reflectivity of this fictional frame story within which the memoir appears enables the narrator to create a story out of his inability to create stories; to take his career forward by pronouncing it stuck and reviewing how it got to where it presently is:

> [L]ike prudent navigators we may reckon our course by deducing where we are from our running plot of where we've been. [...] '[C]oaxial esemplasy': the ongoing, reciprocal shaping of our story (in this case, a story of our life) by our imagination, and of our imagination by our story thus far. (*OUT* 20)

Clara Bartocci (1995) has quite rightly noted that *Once Upon a Time* should not be regarded as an autobiography of Barth, but rather as the autobiography of his novels – or even, as I would suggest, the autobiography of his narrative imagination personified as 'John Barth, Esq., Author'. In this way Barth manages to combine the notion of chaos as emergence with an authorial presence which does not refer to an absent outsider, nor blocks out the life of the text.

As to whether narrative orders life experiences or actually creates those experiences in the form we have them, the answer is, typically for Barth, not either/or, but a paradoxical both-and. The authorial persona is constructed by the stories he tells, but because of the explicit connection between the persona and the actual author, the implication remains that there are life experiences that precede that narrative and on which it is constructed.

The Ageing Body of Work

Whether defining Barth's writings as fictional autobiography, autofiction or autobiographies of his fictions, and their self-referentiality as sheer repetition, metafiction, intertextuality or pastiche, we should note that the presence of his self-referential authorial persona has become more and more pronounced in each of his recent books. The emergent, holistic shape of Barth's

corpus is the result of the reflectivity between the authorial persona and the structures of story-telling which create that persona and at the same time themselves arise from his presence in the books. One of the effects created by this persona is that the reader's attention is focused on the author's name and on an authorial identity behind the novels. 'I'm going to maintain', Barth (1992/1995: 188) writes,

> that the first and the final question that a storywriter puts to his or her memory, regardless of the subject and kind of story in progress, is not, as we usually take it to be, the question 'What happened' but rather the essential question of identity – the personal, professional, cultural, even species-specific 'Who am I?' […].

Once Upon a Time, Barth's most explicit answer to that question, suggests not only that individual human identity emerges out of the self-reflective sensory data of our experiences, but also that for an author the answer lies in the history of his writings, the words and sentences 'which hang together like the acts and stages of a meaningful life and are in fact mine's meaning, anyhow its most tangible expression' (*OUT* 323). Thus Barth conducts his re-iterations not only in order to continue his career, but also in order to ensure that his writings form a single body of works in which the proliferation of meaning is constrained by his authorship.[76] To Tobin's (1992) presentation of Barth's struggle to continue the life-span of his narrative imagination, I would therefore add his continuing achievements at closure, both within individual works and across his career as a whole. Furthermore, I suggest that his works, as the 'tangible expression' of his narrative imagination, are embodied, humanist posthuman stories about stories.

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[76] Alan Lindsay (1995: 44) has argued that Barth creates a variety of authorial personae who all, in turn, attempt to 'dominate' the entire collection of text. Lindsay focuses on the essay collection *The Friday Book*, but implies that the struggle between different personae extends to Barth's fictions as well. I would argue, however, that the slight differences between one work and the next actually makes the single authorial persona deeper and more life-like as it varies its tone according to different genres and situations.

One reason for the creation of Barth's unusually strong authorial persona may lie in his vision of what the purpose of fiction may be in the lives of human beings. On the one hand, for a writer fiction is a form of procreation, and writing alternate identities can entail living more lives than usual. The single biological life available to an author can be infinitely multiplied and extended through the creation of fictional lives, the 'Scheherazadesworth of stories' that all our lives have the potential for. 'There is no other life', no afterlife or rebirth of a transmigratory soul, quips another one of Barth's author-characters: 'That's why some of us make up stories' (*OS* 92). In *Once Upon a Time* Barth has multiplied himself firstly, by constructing the double temporal structure and the two autobiographical narrative voices (the narrator and 'the Author'), and secondly, by creating in Jay Scribner a character who functions as a foil and trickster figure (Bowen 1999: 195), but is also yet another alter ego to those authorial voices. Through all these different personae Barth alleviates his anxiety of continuance and postpones his own writerly end by creating infinitely regressing, personified copies of his literary imagination.

On the other hand, Barth is much persuaded by the theories that human consciousness is to a large extent dependent on narrative, and that the creation of fictional narratives helps us recognise and modify the structure of our own life stories (Barth 1992/1995: 192-196). In the early nineties Barth found the perfect symbol for his conception of the relationship between fictional story-telling and our life stories in Daniel C. Dennett's description of the editorial process through which the brain creates the feeling of coherent sense experience. The unified self, Dennett (1991/1992) argues, is produced by a process of selection and self-organisation from the fragmented activity of different regions of the brain, a process which perhaps solves, with the help of emergent complexity, the paradox I described at the beginning of chapter 3. Barth sees in this a perfect analogy to the way his imagination and the story being told by that imagination interact and shape each other. Citing Dennett and the German philosopher

Hans Vaihinger, Barth writes about the self as a 'Center of Narrative Gravity' which is created in the act of creating a narrative about itself. Once more turning to Scheherazade as a symbol of narrative creativity, Barth (1995: 195-196) equates her with the '(fictionalistical, *as-if*ish) scenario-spinner that is the continuously auto-creating self of every one of us'. Or as another neurophilosopher Antonio Damasio (1999: 191) puts it:

> The story contained in the images of core consciousness is not told by some clever homunculus. Nor is the story really told by *you* as a self because the core *you* is only born as the story is told, *within the story itself*. You exist as a mental being when primordial stories are being told, and only then. [...] You are the music while the music lasts.

Thus 'John Barth, Esq., Author' is an identity which emerges out of the reiterated relationships between the life of the actual author and the various stories told of it. He is the one telling the story that tells us about who he is.

I would also argue that the emphasis on a balance between motion and rest, between continuance and closure which was shown to be present in *On With the Story* (see 2.3), can also be seen in Barth's entire body of works. Slethaug notes in *Beautiful Chaos* (2000: 6) how a unifying frame extends over Barth's oeuvre and that at least since writing *Letters* Barth has consciously perceived his own works 'not just as a corpus and canon, but as a system with negative feedback, cyclical growth, and certain kinds of erosion'. Although Slethaugh's vision of Barth's corpus as governed by 'cyclical growth' is certainly correct, he also suggests that the point of the repetitions is to bring forward 'the problems with unpredictability in systems and their nearly inexplicable failure' (Slethaug 2000: 7). I would argue, however, that Barth is more interested in the emergent complexity of form and meaning than in unpredictability or the failure of systems. Narrative fiction in general is for Barth a self-perpetuating loop of ever-repeating (though not exactly repeating) patterns, which in themselves consist of infinitely divisible moments of narrative time, yet inexorably move towards their own extinction. By adopting the vocabulary and im-

agery of chaos theory Barth is able to give symbolic form to his thoughts on the paradoxical nature of stories.

It is also interesting to note, in connection with the discussion in section 2.3 of literary works as both objects and processes, that the feedback within Barth's body of works appears not only in the temporal, narrative structures but also in the choice of figural effects through which his authorship appears to readers. Although the concentration on the structures of story-telling in Barth's works shows a clear focus on narrative as a means of telling ourselves who we are, the temporal sequence is often subsumed within what could be called a three-dimensional structure, and any understanding of how the events of the story actually relate to each other can only be gained from attempting to visualise it. The Fibonacci spiral is one such structure, another is the Möbius strip. Similarly, the repetition of individual phrases, images and metaphors creates coherence to Barth's authorial persona through linkages between images rather than through a conventional narrative. The authorial identity is thus not only *told* by his narratives, but it is also *shown* through the flashes of recognition gained from yet another image of Scheherazade on her couch, of the sailboat as a dramatic vehicle, of a pen that, Escher-like, writes the author into existence.

In section 2.3 I also described the chaos-inspired narrative frames Barth uses in *On With the Story* and argued that rather than implying the fragmentation of narrative cohesion, the bending and buckling of those frames suggests, instead, their robustness. Furthermore, because of Barth's commitment to the reflective frame, achieving not only continuance but also closure in his career assumes perhaps more importance for him than for most authors. His fictions since *Once Upon a Time* have all been in some form or another representations of ending – complementing each of his previous books and completing the frame of his career with each publication, just in case it turns out to be the last. Thus Barth has turned the main argument of 'The Literature of Exhaustion' into a personal career project, seeking to show the validity of repetition as an aesthetic while at the same time framing and reframing his

own literary career. *Once Upon a Time* is his first last novel and wraps up the story of his vocation, whereas *Coming Soon!!!* (2001), a reiteration of his first novel *The Floating Opera* (1956/1980), becomes a last first novel. The short-story series *On With the Story*, *The Book of Ten Nights and a Night* (2004) and *Where Three Roads Meet* (2005) all deal with the approaching end of life and of story-telling.[77] By repeatedly constructing such frames to his career Barth manages to have his closure without the ending and to keep on writing new fictions by John Barth, even while exhausting (in the sense of completing) his own body of works with each new book.

Finally, Barth's corpus makes yet another pun involving story-telling and the authorial identity: that of an embodied human author producing a body of works through which his narrative imagination also gains an embodied existence of sorts. In many ways, I suggest, his writings exemplify the call made by Hayles (1999) for an embodied posthuman. A recent example of the principle of embodiment in Barth's works can be found in *The Book of Ten Nights and a Night*, another series of previously published short stories with a new frame. The book feeds on Barth's work as a teacher of creative writing at Johns Hopkins University. Not only is it yet another fiction about fiction (and therefore about life), but it is also a how-to book: many of the stories have an exemplary flavour, as if thought up to illustrate a particular issue in the craft of story-telling, making the book into a fictionalised version of an introductory course: Fiction Writing 101. In this series Barth (2004: 4) uses computer terminology to define the difference between the narrative imagination and the author as the separation between the 'capital-A Author' who is 'the mere narrative hardware', and 'Graybard', the software of story-telling.

While Graybard lacks the 'hardware' body of the author himself, it is clear by his explicitly sexual contact with the 'brackish tidewater marsh-nymph' who is his Muse (Barth 2004: 1) that the narrative imagination is by no means disembodied. As I briefly mentioned in section 2.3, sex and story-telling have always been

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[77] Another series, *The Development*, appeared in October 2008.

intertwined in Barth's fictions, and erotic encounters between author-characters and their spouses, or the narrative imagination and his muse, appear in various guises in almost all of his works.[78] The central point to make of the connection between sex and story-telling in Barth is that even if his writings are intensely metafictional and engage in various kinds of reflective play with language and with fictionality, they never leave behind the embodied experience of individual human beings. His fictions, Barth (1993/1995: 112) writes,

> certainly *are* to some extent about themselves and about the phenomenon of storytelling, but various of them have also managed to be 'about' such matters as the problematics of history, of love, and of personal identity; about the myth of the wandering hero as it applies to our lowercase lives; also the locale of tidewater Maryland, the several differences between art and life, and (on the other hand) the equatability of narration – of the transmission and reception of stories – with being humanly alive.

The fact has to be admitted that reading Barth's fiction has become an exercise in *déjà vu*, and especially in the last ten years some might feel that if you have read one book by Barth, you have read them all. It could therefore be argued that if literary value is considered to be originality understood in the stereotypically romantic sense of unique genius residing in a single work, Barth might seem to have failed as an artist. Taken together, however, his books form a single work of literature in which the intersecting themes, images and narrative techniques make the whole into more than the sum of its parts, and the narrative of the writing of these works is interwoven with the individual stories they tell. Barth's aim has always been to build on the postmodern aes-

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[78] Surprisingly little has been written about love and narration in Barth. On the early fiction, see Farwell (1974/1980) and for a brief nod towards the presence of this theme in the later fiction, see Harris (1995), who is not, however, explicit about the connection between sex and stories. Barth's autobiographical narrator in *Once Upon a Time*, however, notes that the bedtime stories of Scheherazade made the coupling of sex and stories so familiar to him that when he finally found out about *pen* and *penis* sharing an etymological connection, his reaction was only 'a mild Voilà' (*OUT* 267).

thetic which is based on the innovative rearrangement of elements within an emergent structure. In his closing statement at the Stuttgart seminar Barth (1995: 343) ponders on the meaning of the word 'originality':

> 'Originality' is a matter of opinion, I suppose, more than of empirical verification, but to the extent that 'original' means 'novel' or 'innovative' rather than 'aboriginal', that which is 'most original' cannot very well also be 'oldest', since it has to be an innovation from something older than itself, some preexisting state of affairs.

In his works Barth constructs his own kind of originality, in which 'aboriginal' elements are set to interact in novel ways, and new meaning emerges from that interaction. More than once he has referred to himself not as a composer but an arranger: one 'whose chiefest literary pleasure is to take a received melody [...] and, improvising like a jazzman within its constraints, reorchestrate it to present purpose' (Barth 1984: 7). Out of such reorchestrations also arises Barth's authorial identity, which is centred on the concepts of exhaustion and replenishment, on the emergent self-organisation of, if not an 'original', then at least a 'singular' persona from the elements provided both by the author's embodied, individual experiences and by the millennia of human literary past. The real skill for an author (and for all of us) lies in not only recycling old elements but doing it imaginatively within the emergent frame provided by our culture and our life experiences. Thus John Barth's corpus, by concentrating on themes such as authorship, originality, repetition and fictionality, and by harnessing the concepts offered by chaos theory, manages to become a set of interlocking variations on a theme, iterations of a melody which form the opera by John Barth.

Conclusion: Live Stories

Lewis Shiner's novel *Deserted Cities of the Heart* (1988/1989) presents chaos and emergence as symbols for both the unpredictable complexity of human society and for the shape that guides an individual identity. The novel's characters, embroiled in the upheavals of South American politics and Mayan mysticism, learn to see the strange attractor as a vital aid in comprehending the purpose and the pattern in their own lives, and therefore gain the position of freely making informed choices. For Shiner, the attractor is thus not a fate that controls the individual, but a way of conceptualising identity in a way that helps human beings comprehend the shape of their lives and, if need be, act in a way that will push their personal trajectory onto a new attractor.

This chapter has examined the ways in which emergent complexity has been used to answer the question of what kinds of things human identities are and how they can be represented in literature. As with the concept of literary form, which was seen in terms of both object and process, I have tried to approach identity as a notion that entails, in terms of Ira Livingston's analogy, both the chaos of π and the comprehensibility and coherence of the circle. While the multiplicity of the networks which influence the self have been emphasised by many interpreters in the past, this chapter has focused on the ways in which a coherent identity can be perceived as an emergent shape in the dynamics between an individual consciousness and its material and cultural basis. Although ambiguity and multiplicity is present in these interpretations, the authors concentrate more on trying to describe the kind of coherence that the self might have, and how that coherence could be discussed. In particular, the scientists' ability to draw up the strange attractors in the behaviour of seemingly random systems has been taken as a sign of optimism by those who would like to argue for consistency and continuity in the human experience of selfhood.

Another issue which connects this section to chapter 2 is the role of information theory in the understanding of both literature

and the mind. If I earlier focused on how literary works have been conceptualised, this chapter brought out the view of life in all its forms as an evolving system of information processing. Not surprisingly, there exists a wide variety of opinion as to the implications of such a view. To use a few more examples, Carter Kaplan (2000: 161) in *Critical Synoptics* presents complexity theory as an example of intellectual mythology that presents itself as 'dogma, a set of magical or scientific commandments', and he proceeds to dismantle that dogma through the means of Menippean satire. In complete contrast, Eric Jantsch (1980) sees the combination of computation and evolution as the best way of explaining the nature of the universe and human existence. He combines the determinism of evolution with the freedom brought by the process of self-organization, and through this new paradigm, he claims, a 'humanistic' vision 'is finding its scientific foundations' (Jantsch 1980: xiii).

The first part of this chapter focused on bringing out this contrast in what emergent complexity might mean for the humanities. While many scholars have seen information theory as a way of describing how a coherent consciousness and identity could arise in a feedback system of data processing, Hayles (1999) and Waugh (2005) have pointed out potential problems in such a conceptualisation. Both take information theory to undermine embodiment, and Waugh, in particular, connects such a loss of the individual body to the poststructuralist drive towards seeing everything in terms of texts and codes. What their critique shows is that rather than solving the problems of identity and selfhood, cybernetics, emergence and the computational model of consciousness can only present new data for the humanities to dwell on, and that psychology, philosophy, literary theory and other disciplines must continue to try and approach the issues in their own terms. If literary theory is able to take the scientific discoveries and present two seemingly diametrically opposite interpretations of what they mean, it is clear that the answers to the complex questions of identity cannot be found by the natural sciences alone. The humanities in general and literary studies in particular

still have to work out for themselves the most fruitful ways of approaching such problematic concepts – even while they keep an eye on the discoveries being made in the natural sciences.

Literary representations of identity have, indeed, been examined within the humanities without involving chaos theory and emergent complexity. One such field is the study of narrative identity, which aims to shed light both on the way human identity is, at its roots, narratively formed, and on how authors use narrative techniques to bring out literary characters as coherent identities.[79] A valuable element in such studies, and one which resonates with the humanist chaos interpretations, is the notion that identity is no longer a useful concept if it is seen as a monolith. It is important to accept that identity, while by definition it needs to be somehow separated as an entity, is both changeable through time and open to the influence of others.

John Barth's authorial persona is a good example of just such a narrated identity. 'John Barth, esq., Author' is not only open to the influence of centuries of literary tradition, but also grows as time and his literary career go on. By reiterating and reinterpreting the corpus that makes him up and is made up by him, Barth and his narrative imagination draw inspiration and coherence from the past, the maze of time which is not his adversary but 'a resplendent arabesque, a chaos most artfully structured' (*OUT* 324). Further, the authorial persona stops its reflective identity from becoming mere textual play by connecting storytelling with sexual pleasure, and by consciously attaching itself to the details of the actual author's body of individual experience. In all of this, chaos theory provides Barth with a view of identity as 'coaxial esemplasy', as a reflective and dynamic, self-organising whole. His are live stories, narratives which claim the semi-organic, yet crafted status suggested by the romantic metaphor.

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[79] A useful summary of research into narrative conceptualisations of identity can be found in Pettersson (2008). The most comprehensive analysis of narrative techniques used in the presentation of fictional characters' minds is Cohn (1978).

Chaos theory has thus influenced the humanist perspectives on both literary structure and the ways in which identities are formed and represented. There is one further major issue that has engaged the literary interpretations, that is, the question of knowledge. A coherent self which is able to perceive structures in the dynamics of the universe is also able to gain knowledge of that universe. That knowledge may not always be gained through rational enquiry but through an intuitive connection between the mind and world. The self, as Philip Kuberski (2000: 20) suggests, can in terms of chaos theory be viewed as part of those dynamic processes whereby the physical world becomes conscious: 'It may be a principle of reflexivity, the widely distributed event of difference that relates the world to itself'. This paradoxical relation through difference has been viewed as significant not only to conceptualisations of identity, but also to epistemology. Thus in the final chapter of this study I turn to look at the ways in which interpretations of chaos theory connect both the human mind and its literary creations to reality.

4.   The Self-Similarity of Mind and World: Imagination and Realism

> All the seminars [...] had a fatal family likeness. They were repetitive in the extreme. We found the same clefts and crevices, transgressions and disintegrations, lures and deceptions beneath, no matter what surface we were scrying. I thought, next we will go on to the phantasmagoria of Bosch, and, in his incantatory way, Butcher obliged. I went on looking at the filthy window above his head, and I thought, I must have *things*. I know a dirty window is an ancient, well-worn trope for intellectual dissatisfaction and scholarly blindness. The thing is, that the thing was also there. A real, very dirty window, shutting out the sun. A *thing*.
>
> A.S. Byatt, *The Biographer's Tale*

In Rebecca Goldstein's short story 'Strange Attractors' (1993), Phoebe Saunders, a young Princeton professor and a specialist in the geometry of soap bubbles, journeys to the Bures institute in France. The people she meets there, though at first intimidating to her and from very different backgrounds than Phoebe herself, have many simple human experiences in common, such as eating, drinking and love. However, there are also other experiences they share that go beyond the basic biological universals. The scientists and the artists share not only food and drink but also intellectual experiences that are equally human: the pleasure and excitement that arises from abstract thought, and the wonder they feel at the details of the physical world, whether soap bubbles or a rare double rainbow. In the title of the story Goldstein plays with both the general and the technical meaning of 'strange attraction': the characters are unexpectedly and unpredictably drawn to one another, but their interactions are also part of a larger dynamic relationship between the human mind and reality.

This chapter presents a view of literature as inextricably linked to reality and to the various ways in which human beings

gain knowledge of that reality. As with Goldstein's characters, the connection with reality can be based on biological universals or on abstractions, or, most fruitfully, on both. The role of chaos theory in such thinking is to provide a way of conceptualising a connection between mind and reality that is neither mystical nor reductive, but based on the idea of the self-similarity of the universe, on the notion that the same dynamics repeat themselves in various materials and in different kinds of interactive systems. Curiosity about mathematical abstractions leads these authors first to a new understanding of how the physical universe actually functions, and then to the realisation that the dynamics of the seemingly unreachable and inhuman physical reality is in fact mirrored in ourselves, which, in the final analysis, turns the study, representation and understanding of that reality into a humanist project.

Even though some popular accounts have suggested that chaos theory caused an epistemological revolution in science (e.g. Gleick 1987/1998), and some literary appropriations of it have implied that it has similarly revolutionary implications in literary studies (e.g. Demastes 1998: 10), chaos theory has not created a significant change in the way science views its objects. This does not mean, however, that the question is resolved as to what are the implications of chaos theory to the epistemology of literature and literary studies. In *Chaos Bound* Hayles (1990: 16) notes how there has been a radical change in the 'epistemic ground' on which the order/disorder dichotomy rests.[80] The new scientific theories of the twentieth century opened new questions for scientific explanations: general relativity, quantum theory and chaos theory describe behaviour and phenomena that could not be explained by using old-fashioned notions about what is possible (including assumptions about the universe functioning rationally and predictably). On the basis of these scientific developments some critics have drawn the conclusion that since the universe turns out to

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[80] See also Kellert (1996: 231): 'To the extent that our widely accepted frameworks – even frameworks for thinking about human society or art or religion – have been influenced by the physics of regular linear behavior, those frameworks are indeed challenged by chaos theory.'

be inherently irrational and unpredictable, the rational methods of science can no longer be seen as the best way to describe it (see e.g. Porush 1991: 77, 80).

In the context of such developments, it is natural that many of the literary discussions on chaos theory focus on the relation of the individual mind to reality, as well as to other texts and other beings. In the following sections I will examine aspects in the works of Jorie Graham and Tom Stoppard that show how they, like Byatt's biographer in the epigraph, yearn for '*things*' and incorporate the notion of the mind's connection to a chaotic reality into their writing. Where poststructuralist theory questions linguistic reference and the accessibility of reality, Stoppard and Graham focus on finding ways of recontextualising literature in reality, without, however, losing sight of the ways in which literary works differ from other forms of thinking and knowing. In Stoppard's *Arcadia* the connection between the characters and the world exists partly in the form of their mutual physical attraction that follows the rules of gravitation, and partly in the intuitions – the gut feelings – the characters have about what has happened in the past. Jorie Graham also uses chaos theory to explore the intuitive connections between people and things, and her poems display a strong sense of the materiality of the world as well as a desire to convey that materiality in words. Both authors insist upon the connection because they want to emphasise embodiment, but their writings also thematise two further human universals: imagination and curiosity.

As with the concepts of literary form and human identity, there are many aspects in the humanist perspective that draw on romantic notions of art and humanity. Stoppard and Graham emphasise the view of human beings as organisms amongst other organisms, yet at the same time present imagination as a transcendental characteristic which sets human beings into a category of their own. They also focus on imagination and intuition as forms of knowing on a level with the rational methods of the Enlightenment. While such reawakening of romantic epistemologies might seem a step backwards after the poststructuralist critique of

humanist universals, it is intriguing that some theorists (e.g. Waugh 1999, Paulson 2001a, Toulmin 2001) have argued that in re-engaging physical reality and the human biological universals literary and cultural theory is actually stepping into difficult areas of study which the poststructuralist theories bracketed off as unsolvable. '[P]ostmodern Uncertainty is a paradoxically comfortable and reassuring condition', suggests Waugh (1999: 45).

> [It is] a kind of comfortable acquiescence, an assumption of reconciliation which reduces the strangeness of natural and aesthetic worlds to our familiar models and simply dissolves the problem of consciousness and intentionality by writing it out of consideration. The problem for literary criticism, as for literature itself, is how to bring that scientific impulse back from nowhere and into a relation with our human situation, to the kind of indwelling of embodied consciousness, where we begin from, as individuals and inhabitants of a culture. (Waugh 1999: 59)

The 'reassuring' postmodern uncertainty is achieved by making the uncertainty absolute, by making sure that we *always know* we do not know, rather than living with the real possibility that sometimes we know and sometimes we do not. This chapter briefly describes the part chaos theory has played in the re-engagement of literary studies with realist epistemology and then moves on to discuss the ways in which some authors have responded to Waugh's call for combining embodied experience and the scientific impulse.

If chaos theory provides Stoppard and Graham with a reason for epistemological optimism, it also helps them to combine the metafictional techniques of postmodern literature with realist epistemology to form a new kind of literary realism. Thus I suggest that Stoppard's and Graham's departure from the conventions of realism does not necessarily imply a loss of interest in reality, and that metafiction and realism should not always be seen as opposites. Like John Barth, whose autotextuality both creates an authorial presence and comments on its creation, these authors write about reality and about their writing about reality in equal measure. Graham's poetry pushes at the complex boundary between the sayable and the unsayable and in doing so, thematises

that struggle in bodily terms. Stoppard's *Arcadia* uses chaos theory to link up the behaviour of numbers, ideas, and bodies in space, and through such links the play explores the connections human beings have with their physical existence, with the past and with each other. The emphasis on the connections between physical systems, such as heat exchange, and the emotional lives of the characters also reflects on the epistemological questions in the play, and forms a counterbalance to the disrupting force of entropy.

4.1   Realism and the Rules of Dynamics

> She wondered
> if every molecule on the surface of her skin
> was wet and what wet meant to such very
> tiny matter. [...]
> She loved the water trails over her body curves,
> the classical lines between wet and dry
> making graph patterns which she thought might follow
> the activity in her brain – all she wanted
> was to be a good atlas, a bright school map
> to shine up the world for everyone to see.
>
> Jo Shapcott, 'In the Bath'

As discussed in chapter 2, many literary scholars who engage chaos theory in their writings hold the view that the literary work is an object that is describable and comprehensible, even while it exists in a dynamic relationship with its readers. In the following I will discuss two further aspects of the epistemological optimism displayed by humanist literary scholars: the ways in which they use chaos theory to discuss the larger philosophical question of realism, and the way they build a theory of representation on that philosophical realism. Can a literary work represent reality? On what basis is its resemblance to reality judged?

The link between literature and the real world in these writings is primarily based on the conjecture that the human mind and

its products (including literature) function according to the same principles as waterfalls or weather. This notion is illustrated by the poem by Jo Shapcott above. Shapcott's speaker is fascinated by the thought that her mind and body might be replicating the dynamics that rule all matter in the universe. The poem creates the same analogy which Argyros presents in *A Blessed Rage for Order* (see the epigraph to chapter 3) and the speaker wonders how, even though the molecular description of water is different from the description of her wet skin, certain patterns might recur in the 'classical lines between wet and dry' and in 'the activity in her brain'. What the system is made of and what its mechanisms are do not matter to the rules of dynamics – all that matters are the dynamics themselves, which, even at the edge of chaos, contain universal characteristics. 'The whole tradition of physics is that you isolate the mechanisms and then all the rest flows,' says the mathematical physicist Mitchell Feigenbaum (as quoted in Gleick 1987/1998: 174-175). But in chaotic systems 'you know the right equations but they're just not helpful. You add up all the microscopic pieces and you find that you cannot extend them to the long term. They're not what's important in the problem'. What is important are patterns of behaviour, which chaos theory has shown to entail universal characteristics. One of these is a constant discovered by Feigenbaum himself, which expresses the ratio of bifurcations in the behaviour of a system proceeding towards chaos (approximately 4.669:1). Even though the number as such may not say much, its existence as a universal characteristic shows that there are recognisable rhythms in the behaviour of systems as different as developing animal populations and swirling smoke.

By suggesting that the same dynamics extend all the way to the function of consciousness, such universal characteristics connect the human mind to the rest of reality. As humans, we are embodied minds, so the argument goes, and the combination of mind and body is just one expression of the same underlying laws of dynamics that govern complex phenomena in the rest of the

universe.[81] Thus there may be an inherent, though still hypothetical, connection between our minds and the physical universe – one which may be difficult or even impossible to formulate clearly within our rational minds, but which still exists in the imagination.

Mostly such efforts are connected to the traditions of literary and philosophical realism. One of the very few scholars engaging chaos theory and drama is William W. Demastes, whose *Theatre of Chaos* (1998) explicitly aims to formulate a new kind of dramatic realism, a 'chaotics realism' (1998: 33), which would 'provide a "scientific" description of reality as it is experienced by human beings' (1998: 128), a description which would be based on the new physics and expressed through new dramatic techniques. Demastes' strategy is to look for a third way between the two major dramatic traditions influencing European theatre in the twentieth century: naturalism and absurdism. Chaos theory, he suggests, offers such a way, since it provides a middle ground between the hubristic control of naturalism and the absurdist despair of randomness. All three approaches, however, share the assumption that theatre has to do with how the universe is – the only question being whether it actually is determined or random, and to what extent can it be controlled by human actions. Indeed, although he does not explicitly put forward any kind of scientistic argument of science over art, Demastes (1998: 149) suggests that 'an understanding of nature seems a critical priority, the antecedent to any valid approach to or philosophy of human existence'.

However, as I suggested in chapter 1, chaos theory has more commonly been taken as supporting poststructuralist epistemological uncertainties. Such interpretations have their roots in the undeniable unpredictability and nonlinearity of the universe. While for centuries mathematics concentrated on linear, easily solvable systems and even ventured to suggest that nonlinear systems are exceptions in a mainly linear universe, thinking of linear systems as the norm is now seen as rather absurd:

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[81] One of the more eloquent accounts of the interconnection of everything through the laws of dynamics is John Gribbin's *Deep Simplicity: Chaos, Complexity and the Emergence of Life* (2004/2005).

> To call a general differential equation 'nonlinear' is rather like calling zoology 'nonpachydermology'. But you see, we live in a world which for centuries acted as if the only animal in existence was the elephant, which assumed that holes in the skirting-board must be made by tiny elephants, which saw the soaring eagle as a wing-eared Dumbo, the tiger as an elephant with a rather short trunk and stripes, and whose taxonomists resorted to corrective surgery so that the museum's zoological collection consisted entirely of lumbering grey pachyderms. (Stewart 1989/1997: 74)[82]

During the 1960s and 1970s the science of 'non-elephant animals' developed, until books like Gleick's and Stewart's appeared, spreading the word among non-specialists, and, together with concepts such as Heisenberg's uncertainty principle and the bizarre paradoxes of the quantum world, the unpredictability of chaotic systems was taken to hit the final nail into the coffin of such Enlightenment ideals as knowledge, reference and control (Cordle 1999: 75-105).

However, those whom I would describe as humanist feel an affinity with the enthusiasm displayed by the chaos theorists themselves about the way their discoveries have actually *extended* the field of our understanding to cover phenomena previously considered incomprehensible. If we cannot exactly predict the weather, at least we now know *why* we cannot do so, and can use that new understanding to make the predictions better than they were before, even though they will necessarily remain fallible. In direct opposition to the assumptions of poststructuralist literary theory, chaos theorists themselves continue to argue that their discoveries do not imply an absolute limit to what can be known or understood, only to what can be predicted. Rather than exploding inquiry into innumerable individual points of view, they emphasise the shared characteristics in systems as different as turbulent liquids and double pendulums.[83] As Harriett Hawkins (1995: 36) has noted,

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[82] Gleick (1987/1998: 68) attributes a similar analogy to the mathematician Stanislaw Ulam.

[83] The study of chaos mathematics has resulted in some practitioners referring to the field of 'experimental mathematics' that reflects the way the cal-

chaos theory may prove as challenging to certain axioms of literary theory as it did to cherished scientific assumptions. For in marked contrast to many influential literary theorists, the most influential chaos theorists and practitioners repeatedly insist that whether we like it or not, there is 'something' of universal (not exclusively culture-based) relevance that lies outside their texts, and for which their texts themselves are but approximations, symbolic images, metaphors.[84]

The perspective identified by Hawkins in chaos theorists is actually also present in the work of a number of literary scholars, who rather than assuming an overwhelming primacy for language and texts, are keen to redefine the relationship between literary works, their study and the world in a way that retains the specific character of literary art without severing it from the physical world.

From the Scriptoral Metaphor to Philosophical Realism

One reason why a single scientific theory can give rise to two interpretations as different as the poststructuralist and the humanist views of chaos lies in the metaphorical structures that govern our ideas of what knowledge is. The scriptoral metaphor, which according to Waugh (2005) rules most of the current writings on science and literature (see pp. 65-66) guides us into thinking of existence as (chaotic) information flow to which there is no outside with which to interact. To such a view knowledge, too, appears as constructed internally within the information flow, with nothing to separate the information from the world it describes. Such an internally constructed system of knowledge represents a completely self-consistent structure. However, in a system where knowledge is created with external reference it is easier to allow for representations to be incomplete and subject to change. By building on a definition of knowledge that allows such incompleteness and which relies on external reference, the humanist

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culations cannot be ascertained from known axioms but are set to run in a computer and the results observed afterwards. (see Harris 1997: 136)

[84] See also Paulson (2001b: 79).

view of chaos also accepts a degree of realism not allowed by the poststructuralist interpretations. The mutability of chaotic systems supports the idea of knowledge as changeable, but the stable patterns that exist within the seeming disorder also create a heuristic base on which to build representations. We may never be absolutely sure about anything, but that does not mean that some statements would not be truer than others. In *Chaos Bound* Hayles (1990: 209-235) presents the dialectic between accepting a degree of uncertainty and demanding absolute rationality as that between 'local knowledge' and 'global theory'. Their interaction, Hayles (1990: 232-233) suggests, will always mean that while they 'may each attempt to deny the other by extending its boundaries, when one is pushed to the limit, the other returns'. What I see happening in humanist approaches to literary epistemology is a movement away from global theory and back towards local knowledge, but with the added emphasis on a shared physical reality as the context of that knowledge.

As discussed in section 1.3, William Paulson (1991) regards different scientific disciplines as different forms of information processing where new information can be created by combining one level of description with another, or with an object not usually viewed in terms of that particular level. Paulson (1991: 45) further points out that accepting that some systems are more than the sum of their parts already commits researchers to a more pragmatic epistemology, and that '[t]hose who describe phenomena as complex or emergent thus renounce the Cartesian dream of maximal certainty by reduction to the simple, and assume the risk of choosing a pertinent level of description'. The difference between levels is not in the number of details which could be reduced to a lower-level explanation, but in the dynamic interaction of those details, which makes every instance unique and every description partial.

Such an epistemology is not exclusive to literary interpretations of chaos theory. In *Return to Reason* (2001) Stephen Toulmin continues the argument he first made in *Cosmopolis* (1990/1992), according to which the rise of rationality at the expense of rea-

sonableness in the seventeenth century was, among other things, due to the desire for absolute certainty on which to base theological and scientific arguments in order to prevent further religious wars like those of the early 1600s. The combination of scientism and scepticism in poststructuralist literary and cultural theory results from that same desire, for once it became clear that the first axioms cannot be found, the whole system of rationality supposedly collapsed. Toulmin (2001: 204-214) advocates a return to a Renaissance balance between the theoretical and the practical arts, where instead of truth being built on absolute axioms, personal experience forms the roots of a system of theorising and most questions have more than one reasonable answer. The major difference between Toulmin's position and that of poststructuralist theory is that the different answers are not themselves absolute and therefore incommensurable but situated and practical, and can therefore be discussed. Thus Toulmin advocates reasonableness based on contextual evaluation over strict rationality.

This conception of reasonableness based on external reference can further be found in literary epistemology, especially in Paisley Livingston's (1988) views of specifically literary knowledge. If the natural sciences are taken as valid but not algorithmic ways of looking for the truth about the world, Livingston argues, literary studies themselves would be freed from the impasse created by the requirement for axiomatic and absolute knowledge. In order to define those aspects of natural scientific theory that should be adopted into the humanities, Livingston calls upon a realist epistemology which would accept that science, on the one hand, cannot form a perfect algorithm for life, but, on the other hand, is not completely isolated from other human concerns. The benefit in accepting the fallibility of knowledge is, according to Paulson, Toulmin and Livingston, that it makes possible a non-absolute, non-reductive model for how the mind can gain information from reality.

Such scholars base their thinking on the existence of an external, physical reality which does impinge on human minds and which can be described in language, even if not with absolute pre-

cision. Such philosophical realism is the first step in the formation of a humanist approach towards chaos and literary epistemology. The second is to connect philosophical realism to the realist tradition of literary representation.

Mimesis through Universal Dynamics

In her incisive study of nineteenth-century realism Lilian R. Furst (1995) argues that even the traditional realist novelists had neither a naive nor a monolithic view of what representation of reality in literature might mean. Even though her stated aim (Furst 1995: 16-17) is to 'extricate realism from the quagmire of mimesis' and to argue that realism should not be equated with a referential purpose but rather with a desire to create a credible illusion, Furst (1995: 12) also allows for the credibility of the illusion to be judged in relation to a shared reality: 'It is the sustained dialogue between reference to actuality and the textual creation of a fabricated realm that is the distinctive hallmark of the realist novel', she argues. For expressing this dual nature of the realist novel Furst (1995: 36-38) adopts Benjamin Harshav's (formerly Hrusovski) view of an equally dual system of reference: that of 'external' and of 'internal' reference. 'The realists are, indeed, conspicuous for holding their texts open to outside data, appropriating them in order to make close connections between the real and the fictional domains,' she suggests.

> The external field of reference [...] merges seamlessly with the internal one. The conversion that is abrupt in the deviance of the poem is so gradual and gentle in realist fiction as to be virtually imperceptible. [...] It makes constant use of a dual system of reference, to the point where its slippery pretenses even blur the distinctions between apparently ordinary sentences and possibly deviant ones. [...] The coexistence of the dual system of reference is at once a consequence, and expression, and a reinforcement of the porosity between the real and the fictional worlds. (Furst 1995: 45)

Following Furst's application of this dual system of reference, a literary work, when it is understood in terms of its process-like characteristics, could also be seen as a combination of kinds of reference and with various epistemological purposes.

Furthermore, the conceptual separation between external and internal reference creates an important parallel with certain strands in recent discussions on mimesis. Rather than being seen simply as a form of copying reality, scholars such as Paul Ricoeur (1983/1984) and Stephen Halliwell (2002) have understood mimesis in the Aristotelian sense as both invention and discovery, as imitation that is a re-enactment rather than a copy.[85] Halliwell (2002: 22-24) convincingly argues that the mimetic tradition is much more varied than the common translation of the term as 'imitation' allows, and that the debates over the different versions (and, indeed, over whether the concept should be applied to art at all) have taken place between two different attitudes to representation: an 'outward-looking' or 'world-reflecting' view on the one hand, and a more inward-looking or 'world-creating' view on the other.

> On the first of these interpretations, mimesis incorporates a response to a reality (whether particular or general) that is believed to exist outside and independently of art. It engages with this reality, or at the very least with other experiences and perceptions of it, and has the capacity to promote and enlighten the understanding of it. On the second interpretation, mimesis is the production of a 'heterocosm' [...], an imaginary world-in-itself, which may resemble or remind us of the real world in certain respects (and may thus in some cases be partly a matter of 'worldlike' consistency or plausibility), but is not to be judged primarily or directly by comparison to it. (Halliwell 2002: 23)

Based on Halliwell's definition, the outward-looking interpretation of mimesis views the world as a necessary element in art and suggests that in discarding its worldliness art would lose one of the

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[85] Even Furst (1995: 60-61) rehabilitates this sense of mimesis at the very end of her study, where she argues that although mimesis as mirroring is a useless concept, it becomes vital when understood as skillful enactment.

aspects that make it most valuable to human beings: its cognitive function as a producer of new content for human thought. This does not mean, however, becoming blind to the creative and imaginative nature of art, but rather it is an understanding that both are needed, even if different works of art emphasise the two aspects in different ways.

In fact, mimesis is not an issue generally discussed in conjunction with chaos theory. Hayles (1990), for example, while admirably covering the reciprocities between chaos theory on the one hand and identity, the experience of time and literary form on the other, does not directly comment on representation or mimesis. She views chaos primarily as the noise in the message, and due to her focus on poststructuralist theory, she is not interested in discussing the interfaces between chaotic dynamics and reference.

Argyros, on the other hand, spends half of his book *A Blessed Rage for Order* (1991) on establishing a connection between the dynamics of literature and those of reality, a connection which derives from seeing the universe as a series of evolving hierarchies. He further suggests that the reproduction of dynamic forms from level to level is a form of mimesis. As I indicated in section 3.1, one of Argyros's suggestions is that literature is nonlinear because reality is. Strange attractors restrict the behaviour of a chaotic system to a particular area of phase space while still allowing it an infinite number of paths to take within that restricted area. Similarly narrative, Argyros (1991: 319) suggests, 'exists in the economy between Platonic fixity and Foucauldian relativity – describing a form which is at once cross-culturally universal and locally ductile'. Furthermore, because of this similarity in dynamic form between narrative and nature, he argues, '[n]arrative is indeed mimetic. It imitates nature' (Argyros 1991: 321).

Argyros focuses on the universality of chaos dynamics, and combines them with evolutionary theory and Jakob von Uexküll's semiotic *umwelts* to form a cosmology in which human cultural production is part of an evolving, hierarchical system that encompasses everything from subatomic particles to poetry. In such a universe the human mind would not be an outside observer able

to rationally access knowledge, but part and parcel of it: 'The mind simply does the work of nature at a higher pitch, that is, it is more active, spontaneous, generative, hierarchical, and creative than the lower evolutionary levels of which it is composed' (Argyros 1991: 187). The connections within such a system bring the physical universe within the scope of human thought, making both scientific knowledge and literary representation possible. A human knows what it is like to be a rock, Argyros (1991: 182-184) suggests, because she is subject to the same physical laws of inertia, gravity etc. that rule the *umwelt* of the rock. While the connection is real, accessing it with the conscious mind is more difficult. The only ways of expressing such knowledge in language are abstractions: 'level-specific knowledge of the world of a rat or a rock is, for the most part, so primitive that it is, in principle, unavailable to conscious reflection except as a top down theory or fiction' (Argyros 1991: 183).

If chaos theory helps Argyros to connect mind to reality, the same is true of narrative:

> A narrative is a hypothesis about the nature of an existing slice of reality or about the potential consequences of certain variations on a model of the world. Inasmuch as narratives tend to be shared, they perform on an intersubjective, cultural level what our central nervous system does at the level of the individual. (Argyros 1991: 316)

Thus both fictional and factual narratives are another reflection of the universal complex dynamics that are expressed in all the different *umwelts*. Since chaos theory reveals how a system following simple laws can develop fantastically complex behaviour, Argyros (1991: 316-321) also argues that it helps us to accept the fact that human beings will map their world through causal narratives. In Argyros's thinking chaos theory shows that deterministic phenomena can still be amazingly complex, and therefore there is no reason to fear, as Lyotard (1984) does, that our preference of grand narratives would automatically make our conceptual universe more simplistic:

> A common presupposition of contemporary thought is that complexity and teleology are engaged in a zero-sum game – a relation in which an increase in teleological dynamics must be paid for by a decrease in complexity. Implied in such a view is a conception of teleology as a deterministic frame inimical to the indeterministic richness of complexity. I believe that chaos offers a model of complexity which can correct this widespread notion by allowing for a relation between complexity and teleology that is best understood as a mutually enhancing feedback loop. (Argyros 1991: 317)

This view, Argyros argues, could end the solipsism in which literary studies found itself in the late 1980s. '[T]he only nonmetaphysical way around the impasse generated by the apotheosis of textuality', Argyros (1991: 6) writes, 'is through a kind of foundationalism based on a view of the universe as a communicative, dynamical, and evolving system', whose dynamics depend on a complex network of interacting, self-similar hierarchies. Accessing knowledge between different levels can be done through either the supposedly top-down methods of science or through embodied knowledge and imagination, both of which have their limitations.

Argyros's argument about the chaotic connection between mind and world explores the same ground as the discussions on mimesis. The embodied knowledge of the *umwelt* of the rock which he envisions is unavailable to rational thought or straightforward representation, and it can be accessed only by the experience of certain laws of physics, and only represented by a 'fiction'. Similarly, the concept of mimesis as artistic representation depends on the separation of certain elements of human experience as accessible only to intuition and imagination. However, as discussed in chapter 2, humanist interpretations do not lead to a view of art just for art's sake, but contextualise the work of art in an external reality. Literature, rather than being entirely autonomous imaginative activity, is viewed as one way in which human imagination replicates the chaotic dynamics of the physical world and produces works that are artificially autonomous in Paulson's (1988: 135) sense. A similar argument will be made further in this

chapter about Graham's and Stoppard's writing, which suggests that both are realist authors of sorts. However, in order to navigate between the variety of ways in which 'realism' has been understood in literary scholarship, it is necessary to specify that these recent writers are *externalist realists*. I derive the term 'externalism' from epistemology and use it here in the sense suggested by Mark Rowlands (1999: ix): 'the idea that the contents of the mind are, in some sense at least, *worldly*: they are environmentally constituted'. Although I do not follow any specific or philosophically defined sense of externalism, my use of the term roughly follows the epistemological division between externalism and internalism; that is, justifying knowledge through a fallible embodied and external reference rather than through self-consistent internal reflection alone.[86]

Externalist realism is thus a view of the nature and purpose of fiction and it acts as an identifying label for those works of literature and literary criticism that take the existence and the relevance of a shared, physical reality to be one of the major elements in literary communication. Naturally, this does not mean that they would present literature as just another form of non-fictional discourse. The assumption made by externalist realism is that literary works are representations that function on the basis of their reference to reality, but are not limited to it. To this assumption is added an interest in the discoveries made by science, which together result in works that focus on the ways in which our knowledge of physical reality, whether human bodies, other organisms or elementary particles, can be expressed through artistic means.

As my two exemplary authors are a poet and a dramatist, it is clear that externalist realism is not limited to narrative fiction, but includes works of prose, drama and poetry as well as literary criticism and theory. Although my definition arises from the limited

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[86] For more on exernalism in epistemology see Luntley 1999. I have previously used 'externalism' as such as a term to describe this literary phenomenon (Polvinen 2003: 50), but found it necessary to adopt the more specific term of 'externalist realism' in order to contextualise it better within the field of literary studies.

number of authors and scholars whose works both refer to chaos theory and display an externalist realist attitude, I also believe the term can be useful in defining a much larger phenomenon in contemporary literature.[87] In the final analysis, externalist realism is like literary realism in general in that its aim is to present reality largely as it is, but rather than concentrate exclusively on the realities of human experience and social interaction, externalist realism also attempts to present to readers forms of physical reality that may be, and often are, as far away from normal human experience as can be imagined. Stoppard and Graham, for example, write about cosmology, quantum mechanics and chaos with the aim of making these phenomena present in readers' minds, and not only

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[87] Some further theoretical fields are useful to mention in order to triangulate the position of externalist realism: biopoetics, ecocriticism and phenomenology. Biopoetics is a theoretical outlook which sees literature in terms of evolution, particularly evolutionary psychology (see e.g. Carroll 1999). Although externalist realists share with biopoetics their appreciation of what science has been able to discover about the physical context of human existence, the focus of biopoetics is almost exclusively on explaining the behaviour of literary characters in terms of evolutionary principles. Similarly, ecocriticism begins with a principle shared by externalist realists: that there is a relationship between the human mind and its environment and that it is interesting and valid to examine how that relationship is expressed in literature (Glotfelty 1996: xix). However, the actual practice of ecocriticism tends to concentrate only on the biosphere: on human interaction with the natural environment. The externalist realists have a wider and perhaps more philosophical interest in the relationship between humanity and the surrounding universe. They do not limit themselves to the planetary environment or to the level of the human senses, but attempt to approach even more fundamental issues in physics, such as the universal mathematical rules of dynamics. Further, there are certain affinities between externalist realism and phenomenology in the sense that both emphasise bodily experience of the otherness of reality, although they differ in that phenomenologists have traditionally only accepted the experiences available through the senses of an individual (Desroches 2003), whereas externalist realists also embrace the intersubjective knowledge that is derived from the scientific enterprise. Where phenomenology takes the view that the natural sciences represent a world-view which must be supplanted by an individual encounter with an object in all its otherness, for the externalist realists the universe presented by science is a source of inspiration.

because they happen to be a poignant symbol for some aspect of human life. Authors can and should try to talk about physical phenomena; to produce drama, poetry and fiction that shares with science the very human excitement over things that are *not* human.

It is also important to emphasise that the externalist realism I am describing does not assume either positivism or mechanism. The relationship between mind and reality advocated is still a humanist approach, and not described in absolute terms, nor is it explainable through the description of brain states alone. As I argued in chapter 3, this view of chaos theory, particularly the notion of emergent complexity, provides a way of conceiving of the mind as an emergent property which is determined by physical laws but whose behaviour is, nevertheless, unpredictable in terms of those laws. Thus bringing scientific ideas to bear on literature does not in this case imply belief in a totally value-free science, in the supremacy of science and technology, or a physicalist or naturalist reduction of the human sciences to materialist principles. Instead, externalist realists are driven by what Martin Eger (1993: 201) calls the 'cosmological interest': a cognitive drive to comprehend human experience in conjunction with its physical context.

Externalist Realism and Metafiction

When dealing with a theory of physics in relation to literature it is very easy to adopt the assumption that conceptual models reproduce the objects they are modelling. Such a view not only distorts the ontology of art, but also misrepresents the scientific worldview. Trying to match language to reality in a way that would reproduce all the aspects of that reality is of course pointless: the ever-pithy Raymond Tallis (1988/2000: 127), for instance, notes that 'no amount of fiddling with words and meanings could make the word "itchy" itself itchy'. The discussion of how 'itchy' can represent itchiness without itself being itchy is also self-consciously thematised in externalist realist texts and is taken up in discussions over the status of metafiction. While Tallis's point

holds in terms of the details of the linguistic system, there are critics and authors who have suggested that there is something in linguistic representation that replicates not the objects, but the dynamics of reality.

One of the ways in which such a replication has been envisioned is through a particularly postmodern version of mimesis, in which the real is conceived as an unstable field, and literature allegedly reflects that instability. A fractured text is mimetic because, as chaos theory has revealed, reality itself is fractured.[88] One of the less helpful, yet widely spread views of how such structural mimesis appears in literature is comparing the butterfly effect to novel plots where small events have disproportionately large effects on the lives of fictional characters. For example Gillespie's (2003: 70) note that the society of *Beowulf* is sensitive to initial conditions because '[a] warrior's choice of the garments that he will wear to a particular feast can alter the likelihood of peace or war between two peoples' is unlikely to deepen our understanding of the poem. Most authors (e.g. Hawkins 1995: 16) point out that such situations are typical of literary plots, but do not go on to show how viewing the behaviour of plots as chaotic would help us understand them any better than narratology does.

As I noted in the Introduction, Stoicheff's article 'The Chaos of Metafiction' makes the bold claim that 'a metafiction text *is* a complex system' (1991: 85). Equating Barthes's *jouissance* with the generation of patterns by complex dynamics Stoicheff (1991: 87-88) argues that reflectivity makes a metafictional text a chaotic system in which 'the text's limitless potential for interpretation and the author's relinquished power' act like a creative dynamo. However, Stoicheff does not accept the idea that the replication of the functioning of dynamical systems would make metafiction mimetic. 'Metafiction', Stoicheff (1991: 87) claims, 'is a synchronic response to the chaotic nature of its medium, and the structures

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[88] See also McHale (1987: 38), who notes how mimetic effects in postmodern literature 'are accomplished not so much at the level of its content, which is often manifestly un- or anti-realistic, as at the level of form' (also quoted in Slethaug 2000: 7).

inherent in it are a consequence of the dynamics of language, not a reflection of the chaotic phenomenal or ontological realities that all art, in some way, engages'. As Hayles (1991b: 22) notes in her introduction to the collection in which Stoicheff's article appears, Stoicheff 'attributes the convergence between postmodern literature and science to a "narrative of chaos" that is characteristic of the present moment', meaning that metafiction and chaos theory would in Stoicheff's opinion be similar because both are ruled by a master narrative.

Thus Stoicheff suggests that metafiction shares the dynamics of chaos not because it is representative of the chaotic dynamics which occur in the real world, but because such dynamics rule the function of language, and the functions of language are what metafiction represents. Nevertheless, Stoicheff keeps referring to the relationship between the text and the world, and bases his argument of the inherent unnaturalness of non-metafictional fiction on the discrepancy between the simple and ordered fiction and the chaos of the phenomenal world (1991: 85, 91).[89] At the end of his article this tendency becomes a conscious statement of the 'nice irony' inherent in the idea that metafiction unintentionally replicates the dynamics of reality:

> If we were now to take into consideration the possibility that the phenomenal world itself is chaotic, infinitely self-replicating and fractally ordered, the antimimetic properties in metafiction bespeak a nice irony. Metafiction begins with a distaste for purportedly referential or realistic literature and yet, in its reaction against such, nevertheless manifests the structures of the chaotic phenomenal world. The difference is that metafiction generates those structures in itself, and so, although not mimetic of a chaotic world, nevertheless shares its aspects. Just as 'the approximation of a coastline to a fractal is better than its approximation to a smooth

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[89] Similar comparison between chaos theory and the way art simultaneously represents the complexity of life and makes it manageable can be found in Slethaug (2000: xv): 'Since art is a means of imposing order upon experience, it puts under erasure, as Derrida would say, all the flux and nonlinearity that constitutes life, but then reinscribes it through narration'.

curve', so are reality's contours closer to metafiction's than to mimetic fiction's. (Stoicheff 1991: 94, quoting Paul Davies)

I would say that Stoicheff has the relationship between literature and the world backwards: rather than taking literature to be a function of the way we relate to the physical and social realities of our embodied existence, Stoicheff (1991: 95) takes the position that 'our interpretation of our world is a function of our reading of texts'. Further, because his starting point is in the assumption that language rules itself, Stoicheff makes no separation between texts that deliberately invite open readings and texts that do not – that is, he does not allow for either authorial intention or even for textual structures that do not support metafictional readings.

John Barth's metafictional play is an example of a very different view of the relationship between metafiction and mimesis. As discussed in chapter 3, Barth creates an authorial persona which underlines its own constructedness but still comes across as an individual voice. Furthermore, his account in the essay 'Very Like an Elephant: Reality versus Realism' (1995: 136-143) of the relationship between metafiction and mimesis explicitly begins with the idea of 'Reality' with a decidedly capital R. 'It was not invented by "realistic" novelists and painters, although our perception of it can doubtless be influenced by art as surely as changes in a culture's perceptions influence what passes for artistic realism', Barth (1995: 139) declares. What his metafictions depose is not reality but the conventions of realism: the '"Windex" approach' which aims to give readers an illusion of reality by the means of invisible language (Barth 1995: 141).

In general terms, in the Stuttgart lectures Barth (1995: 347-348) views chaos theory as an interesting new way of 'making sense of the world'. At the very end of his last lecture, however, he also makes the connection between chaos theory and the use of metafictional technique in what I would call an externalist realist literature. Being aware of both the dynamics described in chaos theory and of the development of similar dynamics in the history of literature, Barth (1995: 348) notes, makes him as a novelist able to do deliberately what others may do unconsciously. The deliber-

ate use of chaos theory as the self-similar dynamics that connect into a single continuum elementary particles, human lovers and the movement of both galaxies and narratives is evident in *On With the Story* (see 2.3). Rather than go into details of the stories that have already been discussed above, I would like to draw attention to one that has the joy in both reality and language as its core. 'Good-bye to the Fruits' has the simple premise of narrating the experiences of a man who has 'agreed to die', but with the stipulation that he first be allowed to say goodbye to 'those of Earth's fruits that he had particularly enjoyed in his fortunate though not-extraordinary lifetime' (*OS* 192). He begins with 'apples and oranges', but quickly the story expands to talk in sensuous language about more exotic fruits from the lime to the guava, and further, to other foods, to the taste of kisses and to 'those flora and fauna that one eats only with one's eyes', that is, natural landscapes (*OS* 192-196). Finally, after including both humans and their artefacts in his list, he turns, in a way familiar from Barth's earlier use of conceptual loops, to the words that describe all the things he has seen and heard and tasted, 'that most supple, versatile, and ubiquitous of humanisms, language' (*OS* 201). The words form a continuity with things, are about the fruits and about themselves, and both have a value worth celebrating.

The two different attitudes visible in Barth on the one hand and Stoicheff in the other fall into the two different categories of metafiction identified by Patricia Waugh (1984/1985: 53): one which 'finally accepts a substantial real world whose significance is not entirely composed of relationships within language' and the other which 'suggests there can never be an escape from the prisonhouse of language and either delights or despairs in this'. The first of these approaches would quite happily accommodate the idea that the real world is representable, it is only that the methods of traditional realism are inadequate for such a representation. From this perspective it is also perfectly possible for an externalist realist text to accommodate the techniques of metafiction, and the externalist realist attitude and an interest in literary

form are by no means exclusive of each other. As Paulson (2001b: 6-7) puts it:

> Literature is both referential and rhetorical: it helps its readers to interact with both the variety of the world over time and space and the variety of possibilities for knowing and imagining the world through language. Both modes of reading – directed towards the world and directed towards discourse – are parts of the requisite diversity needed for steering an adaptable course and constructing a viable pluralistic future.

Representing the dynamics of the natural world could thus be, at the same time, a representation of the dynamics of art. Such a suggestion is made, for instance, by Sheila Emerson (1991: 162) in her essay on the similarities between Ruskin's view of natural order and chaos theory. Emerson analyses a passage in which Ruskin describes sketching an aspen and finding that the act of drawing seems to function according to laws that go beyond his hand. Ruskin's sketch, Emerson argues, thus becomes 'a picture of the laws of composition, a picture of relations between mind and its objects. The picture is a statement about, not a mere imitation of, two things at once: about how a tree is composed, and about how an artist composes'.

The idea that the conventions of realism alone are not enough to represent a world ruled by chaotic dynamics is also present in Leslie Forbes's novel *Bombay Ice* (1998). In this multi-layered rewriting of Shakespeare's *The Tempest* and *As You Like It*, Rosalind, a half-Indian, half-Scottish journalist returns from Britain to Bombay to see her sister Miranda, only to be almost annihilated by the chaotic forces of monsoon weather and the rampant crime and corruption within the Bollywood movie-making industry. Armed with the knowledge of chaotic weather patterns gained from her meteorologist father, Rosalind sets out to map the patterns of events around her sister's marriage and a series of deaths connected to her new family. She is pulled into the violent world of Miranda's husband, director Prosper Sharma, who is filming *The Tempest*. Sharma's version of the play begins as a realistic film and then, towards the end turns more and more to the lushly the-

atrical style familiar from the fantasy sequences of Bollywood films (Forbes 1998: 382). Jamie James (1998: n.p.) in his *New York Times* review of the novel draws attention to its intertexts: these include not only Shakespeare, but Raymond Chandler, Hollywood noir and other 'baroque encrustations' of literary and cinematic allusions. The mixing of such different worlds into a single narrative creates a 'pervasive tone of literary fantasia', which James judges to be occasionally mannered, but also one that 'makes the reader more willing to suspend disbelief'. The contrast between the fairy-tale perfection of the worlds created in Bollywood films and the phantasmagoric mood of the corrupt and violent movie-making industry which creates those images, underlines the difference between imitation as representation and as mirroring. Forbes's choice of literary technique is voiced by the central Caliban-character, another Bollywood film-director, as a non-realistic way of constructing a true-to-life picture: 'the map of Bombay is reflected in its movies, and just as the best map is not the one that perfectly represents reality, so the best expression of this city cannot be achieved by celluloid realism' (Forbes 1998: 4). Thus the novel strongly emphasises the possibility that non-realist literary forms can, by using the dynamics of chaos, create realistic representations.

Chaos theory has so far been a source of inspiration to several different conceptions of the relationship between mind, literature and reality: it has been seen as proof of the dissemination of meaning in a textual universe and as a way of revitalising realism due to the connection implied by the shared dynamics between mind, language and reality. In the following I shall take a closer look at the works of a poet who does not only attempt to represent reality in words, but also bring that reality into presence within the bodies of her readers.

4.2   Jorie Graham and the Bodily Connection

> He has a feeling that he can't find words for, al-
> though it is to do with his poetry. [...] It is a brief
> knowledge of his own temporary body, all the soft
> slippery dark organs, all the minute interlocking
> bones, all the snaking, fizzing, prickling veins and
> nerves. It is the knowledge that he is *inside* this skin,
> and it is intensely pleasurable because it always goes
> with a sense of the huge sweep and intricacy and
> age of what is *outside* hair, skin, eyeballs, nostrils, lips
> and the helix of the ear. It is the irrational pleasure
> of a creature in the fact that its surroundings were
> there long before its own appearance, and will be
> there long after.
>
> A.S. Byatt, *Babel Tower*

Jorie Graham is a poet who keeps trying to push the limits of the unsayable. Her writing, Graham herself has claimed, is 'an attempt to say "are you there?" to a nonidealist, a pragmatist, a reader who doesn't necessarily even believe in literature; most importantly, though, a reader who doesn't believe that words are telling the truth' (Graham 1987/1999: 232). As the title of her selected poems *The Dream of a Unifield Field* (1995/1996) suggests, Graham's writing is much influenced by scientific ideas, and she is a prime example of an author who, without a formal education in the sciences, is able to absorb current scientific ideas and use them as raw material for poetry. But the title not only refers to one of the unsolved puzzles of theoretical physics, but is also a metaphor for the desire in Graham's poetry to connect reality, experience and language into an interactive whole.

In this dream, chaos theory and complexity appear as ways of conceptualising the dynamics of those interactions, as ways of finding words for the feelings that A.S. Byatt's poet experiences in the epigraph. Adelaide Morris (2006) has drawn attention to the resemblance between chaos theory and the 'linked interactions' that occur in Graham's poem 'Event Horizon' (Graham 1993: 50-

54), where organisation and collapse occur in various systems from the Trojan civilisation to soap bubbles (whose complex geometry Rebecca Goldstein's short story also evoked). In the following I will present more instances where Graham's poetry draws on chaos theory, and argue that at the root of her work is the movement between the pleasure of being inside and the consciousness of all that is outside, as well as the notion that the mind's abstractions could actually be self-similar with the physical universe.

The Physics of the Imagination

Central to Graham's poetry is the dual attempt of establishing the world as the other and yet gaining knowledge from it. An explicit example of the first theme can be found in the opening poem of *Overlord* (2005), which describes a childhood realisation that human consciousness can be absent from its physical moment, that it can move in time and space. In 'Other' (*O* 1-3) the speaker remembers a school day spent at home sick and the moment when the child imagined her name being called out in the classroom: 'I heard it said the second time into the grayish morninglight | over the rows and rows of chairs, the gleaming fullness of them, empty, as children stood. | There was nothing I could do. I saw it as I heard it – "absent" – | said out into the room'.

Next the realisation hits her that the tree outside her window could not do what she just did: '*It could not be | absent.* [...] [W]hat of it could ever retreat, | leaving only part of itself present?' That which has not the human capacity to imagine itself somewhere else, the tree and the physical objects in her bedroom, are suddenly the truly other.

Graham is not, however, satisfied with just establishing the otherness of the physical world, but is equally insistent in gaining knowledge of it. The conduit for the knowledge that passes from the world to the mind is the human body. As Joanna Klink has noted (2002: 189), Graham's project

involves two motions of spirit: on the one hand, coaxing ideas – in their pre-entanglement with things – out of the visible world, that they might be apprehended and recognized; on the other hand, translating ideas into physical realities, bringing them down into the body so that they are particular, concrete, visceral, known.

Ideas and abstractions like imagination and otherness are in these poems embroiled in embodiment and, indeed, rather than taking the abstracting mind and the concrete body as opposing or separate entities, Graham sees the '[a]bstraction in which the body thinks in its unbodily reaches' as 'the crucial metaphysical extension of bodily knowledge' (Graham 1996, n.p.). Like Barth, she builds the bodily conduit between mind and reality by bringing the history of humanity into herself, by processing the myths and turning-points within her writing, thus making the act of literary representation into a 'fractal enactment'. 'This might seem excessive to some', she tells Thomas Gardner in an interview,

> but I feel that poems are enactments, ritualistic enactments, fractal enactments – in language, of historical motions. And in the *process* of them, you experience your accountability. You feel, in yourself, those crucial motions the culture has effected because you feel yourself actually doing them, undertaking them – helplessly, really – in the poem' (Graham 1987/1999: 221).

The embodied experience of things that have not actually happened to that individual body are possible, Graham thus suggests, because of the fractal self-similarity of the chaotic dynamics of the universe.

One example of her explorations of the shared dynamics of mind, body and world is 'Vertigo' from *The End of Beauty* (1987, republished in Graham 1995/1996: 64-65). In this poem Graham makes the force of narrative (in particular the narrative of 'falling' in love) physically felt by describing it as the vertiginous feeling of gravitational pull while standing on a cliff.

> She leaned out. What is it pulls at one, she wondered,
> what? That it has no shape but point of view?
> That it cannot move to hold us?
> Oh it has vibrancy, she thought, this emptiness, this intake just
> > prior to
> the start of a story, the mind trying to fasten
> and fasten, the mind feeling it like a sickness this wanting
> to snag, catch hold, begin, the mind crawling out to the edge of the cliff
> and feeling the body as if for the first time [...].

The third-person narration Graham uses instead of her more usual lyrical first person emphasises the idea of narrative, whereas the stretched fourth line and the outride[90] 'prior to' strengthen the feeling of a body at the edge of a precipice, which the following line plunges into the dizzying fall of story. As Helen Vendler (1995: 77-79) has argued, Graham's long lines and enjambments have a narrative function, extending the narrative space of the poem both horizontally and, through the long sentences, vertically. Vendler also makes the suggestion that the development of Graham's poetry from early short-lined poems to the 'sprawling' lines and outrides of the later ones has to do with her emphasising unpredictability over 'shapely organic form'. To be more exact, I would argue that what has taken place is a change in Graham's conception of what organic form is, a change facilitated by the discoveries of chaos theory and the complexity of biological forms. In 'Vertigo', the connection formed between the physical force of gravity and the mental narrative pull is a typical example of Graham's efforts to bring the physical and the mental together without, however, subsuming one to the other.

The feedback between the otherness of the material world and the embodied human mind is in these poems driven by unquenchable curiosity. Without it, the world recedes into flat ordinariness and the process through which ideas are generated is lost. It is obvious that the natural sciences provide Graham with much of the fuel for her curiosity, and her poems include references to

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[90] This term is adapted from Gerard Manley Hopkins by Helen Vendler (1995: 79) to refer to Graham's 'small piece-lines dropping down at the right margin of their precursor line'.

everything from plant taxonomy to quantum mechanics. What she gains from the natural sciences, in addition to the satisfaction of curiosity, is a new way of looking at things. This new kind of looking is then utilised in her poetry as the ground which, as in 'Vertigo', simultaneously pulls at the lyrical voice and forms an opposite for her. As Gardner (1999: 202, quoting Graham 1997: 44) has noted, the incomprehensibility always present in Graham's poetry 'opens the possibility for renewal – for an encounter with "the world made strange again" in our experience of its impenetrability'.

This meeting with something that resists, something that stays opaque, becomes an ethical issue in 'Upon Emergence', in *Overlord* (20-22). The title reflects the emergent complexity of life: the 'mottled interminable | forms' of plants and insects in the speaker's garden. Secondly, the poem presents multiple subjects for the verb 'emerge': the mind waking to reality, the details of life entering the speaker's body, but also visible surfaces or (mere) appearances. While Graham continues to look for the bodily connection between mind and reality, she at the same time expresses anguish at the thought that such a connection would do violence to the other. William Olsen (1991: 87) has noted that Graham rejects the romantic conception of nature being at its most perfect in observation, that 'the physical world is impoverished unless we grant it the benediction of our attention'. Instead, for her the mind, lording it over nature, may instead be a wrathful and violent God. 'Before I think it, | what is its state?' she asks. 'And if I summon it | to mind, if I begin to summon it? Unbearable | tyranny'. This tyranny towards matter puts the human mind in a position similar to that of God. The speaker of the poem sits, like a deity, 'at the very edge | of the garden, paying out my attention'. She sees the garden, accepts its reality, but when attempting to reach for the existence of the geraniums, the rocks and the birds, finds that she is, in fact, pulling them into her own mind. However, the final poem of *Overlord*, 'Posterity' (O 86-88) returns readers to the gaze on the garden and to the entreaty for the existence of the material other in a more optimistic mood: 'To praise to re-

call to memorialize to summon to mind | the thing itself – forgive me – *the given thing* – that you might have persuaded yourself is | invisible, | unknowable, creature of context – it is there, it is there, it needs to be there'. The 'thingness' of physical reality is what Graham needs and reaches for in poetry, whether it is waves on the beach or grubs in the garden.

The collection *Region of Unlikeness* (1991) also focuses on such impenetrability. Graham takes her title from St Augustine's *Confessions* to signify the areas where the otherness of things, physical reality in particular, makes thinking possible. Throughout the collection there is an emphasis on edges and skins, self-definitions and imposed definitions. In 'Chaos (Eve)' (*RU* 46-53), in particular, Graham blends the seemingly paradoxical nature of chaotic systems as unpredictable yet describable phenomena with a description of the creation of the skin of humanity – the border which shuts us away from the world, yet makes existence possible through the distinction between self and other. The poem opens with the creation of Adam out of skins patched together and filled with life, and with Eve still inside, 'awake, wearing him tight all round her'. In the second section the speaker describes an aged and senile grandmother whose exterior also closes in an infinity of unseen life. The grandmother is seen either as an unmoving body or a mind that cannot be reached, except by a trace on a carpet, left by her shuffling orbits in the family's living room. The trace is both the horizontal figure eight, the symbol of infinity, and Lorenz's butterfly attractor with its pair of different-sized loops (see fig. 2 in the Introduction):

> a figure eight –
>   one wing more pronounced where it wrapped all night
> round the recliner he'd
>   fall asleep in.
> [...]
>   The other wing
> wove round the low table with all the wrapped candy –
>   Here have some, have some, gesturing towards our bodies –

Like a dynamical system which reveals its orderliness once its behaviour is plotted onto a graph, the life of the grandmother, encased within that of her husband and (grand)children, but also inaccessible to them, only reveals its shape after the fact. In the final section of the poem the grandmother's life is finally liberated, like Eve out of Adam's body, and the speaker for the first time experiences the older woman as a person separate from herself: 'The shape took hold. | Stepped free'.

Skin is a central image in 'Chaos (Eve)', functioning both as the container which makes it possible to exist in a single shape and to perceive the shape of others, and as the border which both separates and connects humans to reality. The skin joins the mind to the otherness of the world which, like the behaviour of a chaotic system, can be perceived and even comprehended, but not controlled.

Lyricism and Comprehensibility

A similar link between separation and connection, or fragmentation and shape, can be seen in the structure of 'Chaos (Eve)'. William Gillespie (2006), one of the few critics to have commented on Graham's use of chaos theory, notes that the line and sentence breaks in this poem form a system where foregrounded breaks are, nevertheless, joined into a flow by the enjambments at stanza breaks and the conjunctions that begin sentences and sentence fragments. The result is a dynamic that on the one hand emphasises its fragmentariness, but on the other uses self-similar connecting strategies on different levels of the poem's structure to cohere the fragmented sections in a rhythm.

In other words, the impact of chaos theory on Graham's poetry can also be seen in the balance she builds between disruption and comprehensibility. Graham does not confine herself to chaos in its scientific sense, but combines it with the ancient concept of primordial randomness out of which form is taken. Most of her poems are written in free verse, which Graham defines not as the absence of form but as the dynamic region closest to randomness

(Graham 1987/1999: 227), a definition that matches the chaos theorists' definition of the edge of chaos as the most creative dynamics in nature (e.g. Lewin 1993). The term chaos also designates for Graham the direct opposite of organised pattern, in which case creativity exists in the area between the order and disorder. 'Form, when it has power' she says, 'is form wrenched from its opposite. I happen to favor work in which the potential (or posited) power of chaos is great. Because I believe it is so in the world. It *feels* right to me. So form wrought from a merely suggested, hardly virile, chaos might seem more artificial to me, less trustworthy' (1987/1999: 228).

Once wrested from chaos, form functions as a source of pleasure, and, as was shown to be the case with Stoppard and Barth in chapter 2, it gives readers the beauty of a crafted object as well as the unsettling effects of the possibility of infinite variety. Thus the complexity on the surface of Graham's poems is necessary in order to awaken in readers a state of intuitive knowledge, but at the same time they have certain attractiveness or lyricism. In 'Chaos (Eve)' (*RU* 46-53), for example, the difficulty of the poem lies in the fragmentary syntax and in the conceptual shifts between the bizarre and mythical scenes of the creation of Adam and the domestic ones of the senile grandmother and her past as a wife and mother. However, the rhythm and alliterative structures in the lines themselves pull readers on and help them settle into the poem. The third section begins with a description of a birth – a child out of a womb, Eve out of Adam's body, or understanding from the mass of incoherent thought – a description which consists of a sentence that begins but never actually arrives at a conclusion, and contains many of the kinds of breaks described by Gillespie.

> Because the hole that opens in him is the edge of matter,
> the very edge,
> the sensation of there not being enough
> – that rip – and then the squinting to see
> – what is it out there? –
> out of which the taut beast begins to grow,
> and rapidly, the sensation of lateness pulling up out of

> the sensation of there not being
> enough
>   (as you up out of this now pull) –
> rising up out of the gloom
>   like a name being called –

Readers may flounder through the complex shifts from phrase to phrase without being able to settle on a clear meaning or even a sentence structure, yet the onomatopoeic quality of the effort and rushing in the lines (the monosyllables of 'as you up out of this now pull', and the steadier rhythm of the last two lines provides a calm ending to the rush before yet another shift of perspective. Such lyricism, Graham (1987/1999: 233, 235) believes, maintains a sense of meaning in readers. 'Only music will allow us, as readers to suspend ourselves out into "incomprehension" long enough to awaken that intuitive aspect of our reading sensibility, and permit us to sense it, feel that it *can* "know"'. The knowledge of the poem is an intuitive knowledge, the expectation and hope of which fuels the 'soul-forging pleasures of thinking' (Graham 1990: n.p.).

The effects of this attempt to balance intuitive knowing and 'acquisition of information' are evident in the poem 'The Complex Mechanism of the Break' from *Never* (2002: 33-35), which describes a mind observing a breaking wave, a classic example of both fractal form and the dynamics of feedback. In Graham's description the waves on a beach mirror the way the mind's efforts at description become a feedback process, and thought, while aiming at the external, turns back on itself. The detailed description of the self-similar patterns is both a defamiliarisation of the materiality of the waves and a description of the speaker's thought:

> Up close four different brown retreating furls just now (being forced
>   to forward-break) re-
> entering themselves. Each tripping over each as they are also forced
>   into retreat.

> What is force? My love is forced from me as in retreat
> from love. My gaze is forced back into me as it retreats
> from thought.

The rhythm of the first two lines recreates the rhythm of the waves themselves, rushing towards the edge of the page before breaking into the short outrides, with the continuation between the lines created by the enjambed word 're-entering'. In the following two lines the repetition of 'retreat' at the end of the lines echoes the final word of the second line outride and functions as the representation of the self-similar action of wave after wave and thought after thought.

At the end of the poem, however, the gaze lifts further out to sea, where 'it seems, | nothing but steady forward progress in its perfect | time occurs: onward, onward: tiny patterns which | seen from above must: it is imagined: perfectly: shine'. The balance in the poem is formed between the desire to delve deeper into the fractal details of physical existence and the distance required to see any meaningful shape in the materiality. Both views are partial and what must be accepted is not that they are therefore both untrue, but that choosing the pertinent level of description is necessary and that the most complete picture is gained by combining many partial views from different scales.

In other words, there is a balance in Graham's poetry between the 'essentially futile' act of trying to seize something in words and 'what leaks in between the attempts at seizure' which '*is* the thing' (Graham 1987/1999: 230). The final impossibility of the task is what the poet has to accept in order to achieve a small success. As Gardner (1999: 205) puts it: 'Out of our exhaustion and the collapse of explanation, perhaps we have become quiet enough to notice the very first moments when the multiple begins to form patterns, or the light takes on a shape, or a new diagram begins'. Poetry, as one form of such patterning – as representations of the world which attempt to make the world graspable to a human mind – may be the only real knowledge available of the otherness of the physical world, however much the poet may desire to communicate the presence of physical things. Such pattern-

making cannot be ignored or simply declared defunct, but must be developed in the continuous process of being human. For Graham, the forming of abstract patterns of the world in order to try and make the physicality of existence truly felt is a task that is at once inescapable and never-ending.

In another sense Graham's project is phenomenological: she is trying to meet the otherness of physical reality through love which would give room to its otherness and not reduce it to sameness, as is witnessed by her garden poems. This love of external reality is also strongly present in Stoppard's *Arcadia*, where it surfaces in the form of curiosity about the physical world and about imagined abstractions in equal measure, and in the form of the metaphorical connection made between physical love and gravitational attraction. Such works of literature skilfully balance love as an expression of physical connection and the love of imagined abstractions, and in the final analysis break down some of the assumptions concerning the relationships between physicality, abstraction, science and art.

4.3 Tom Stoppard's Gut Instinct

> Theoretical physicists, and many other kinds of scientists, work in a world of the mind. It is a mathematical world without bodies, without people, without the vagaries of human emotion. [...] The exquisite contradictions and uncertainties of the human heart do indeed make life interesting; they are why God held the apple in front of Eve and then forbade her to eat it, they inspire artists and art, they are why the poet Rainer Maria Rilke wrote that we should try to love the questions themselves.
>
> All that is necessary and good. But I miss the answers. I miss the rooms I could enter, the language that sounded as clear as a struck bell.
>
> Alan Lightman, *A Sense of the Mysterious: Science and the Human Spirit*

> It is not self-evident that articulate wonder is ultimately about articulation.
>
> Raymond Tallis, *The Knowing Animal:*
> *A Philosophical Inquiry into Knowledge and Truth*

As discussed in connection with the structure of *Arcadia* and Stoppard's presentation of the notion of coherent form, the differences between the romantic and classical attitudes to art are central to the play. In chapter 2 I concentrated on how the two views conceptualise beauty as an aspect of either order or freedom. In this chapter the focus is on the way classical art attempted to reproduce 'nature as God intended' (*A* 12), whereas in romanticism art was expected to produce a representation of either nature or the artist's experience. Furthermore, these historical attitudes are in the play connected to a postmodern debate over what (if anything) counts as knowledge in the sciences and in the arts.

In the above quotation Alan Lightman, who gave up a career in physics to write novels, separates the two worlds of science and literature by suggesting that science is to do with clear and simple answers, whereas the world of human meanings will always be fraught with ambiguity and uncertainty. Although Lightman (2000/2005: 178) does find pleasure and import in the world of bodies, emotion and human meanings, he remains attuned to the abstractions provided by science and yearns for the 'magnificent serenity' and 'indisputable rightness' of mathematical equations. In *Arcadia* this continuing dialogue between science, the discourse of abstraction, and literature, the discourse of human meanings, is linked to the epistemological questions of representation, and conducted in the language of chaos theory.

While the play never allows these issues to be simply solved, I will argue in the following that epistemological optimism gains much more ground than cynical doubt. There is a connection, noted by Fuller and Waugh (1999: 4-5), between the literature-and-science debate and the aesthetic developments in literary theory since romanticism which is very close to what Stoppard pre-

sents in *Arcadia*. Whereas the romantics contrasted 'the embodied experience of art to the abstract calculation of science', Fuller and Waugh (1999: 4-5) argue, the poststructuralist position current in the 1990s is one where 'both science and art as kinds of knowledge are suborned by an ideological critique which denies the possibility of any genuinely transcendental experience or disinterested epistemological criticism'. I suggest that Stoppard both deconstructs the romantic opposition of embodied art versus abstract science and, far from taking up the poststructuralist position, he reaches for transcendental experiences through both science and art.

Despite the fact that Stoppard rejects purely rationalistic methods of reaching truth, in his work knowledge still retains a referential basis. However, due to the intertextual and metadramatic techniques he uses, he has been pigeonholed as a theatrical dandy whose work owes more to stylistic play than to a representational purpose (e.g. Tynan 1977, Whitaker 1983, Özdemir 2004). Christopher Innes (1989: 317) claims that Stoppard's plays 'should be approached as intellectual comedy, in which the content of any ideas, however serious in themselves, is far less significant than their role in the theatrical game'. In light of his later works, I would argue, it is clear that Stoppard's plays are much more committed to the representation of reality than they were previously given credit for. To borrow Raymond Tallis's expression, it should not have been self-evident that the articulate wonder of Stoppard's plays is ultimately about articulation. Consequently, the ludic perspective in Stoppard's work is contested by critics who emphasise their mimetic drive. Demastes (1998: 85-103), for example, maintains that *Arcadia* reflects both in its subject matter and in its structure new information about how the universe actually functions. Stoppard's play, he suggests, is part of a the 'chaotics paradigm' which aims to balance the opposing drives of dramatic naturalism on the one hand and absurdism on the other. What I would like to emphasise, however, is the fact that the assumption behind all three dramatic styles is that drama

should reflect the world as it is, whether ordered or disordered (see p. 193).

In addition to the issues of beauty and form discussed in chapter 2, *Arcadia* has a second major theme: the birth and rebirth of ideas from the interaction of reality and the human imagination. The play does not allow a strict separation between science and literature, nor between the worlds of abstract ideas and human meanings. Instead it suggests that human imagination can lead to intuitive truths that are to individuals just as valuable as facts arrived at through painstaking research. The difference between the two forms of knowledge does, however, exist and it lies in the nature of proof. 'You can't open a door till there's a house,' Valentine points out (*A* 79), wanting to show that scientific discovery develops through deterministic processes according to which Thomasina could not have discovered fractal mathematics in the nineteenth century. What the play shows is that Thomasina's intuitions about fractals were correct, but they could not be proven correct until after the invention of computers, and therefore do not count as part of the continuum of scientific discovery.[91] But human collective creativity is for Stoppard like a chaotic system in itself: both deterministic and unpredictable, and involving patterns that, even though they may count as dead-ends in terms of the continuum of discovery, can be perceived after the fact. Thomasina not only acts as a reminder that imaginative leaps

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[91] Fermat's Last Theorem, which plays a significant role in the play, was at the time of writing a sought-after historical and mathematical mystery, and one which had been seen as proof of how individual genius can discover something that hundreds of mathematicians could not reconstruct. A 150-page proof for the theorem was published a few months after the opening night of *Arcadia* by Andrew Wiles, and an article describing the solution was added to the programme (Nadel 2002: 448-449). The 1993 proof was found to be flawed and was replaced by a corrected version by Andrew Wiles and Richard Taylor in 1994. However, mathematicians are of the opinion that even if Fermat did have *a* proof for his theorem, he could not have known the proof Wiles presented, since much of the mathematics used in it were not developed until much later. These real-world events replay nicely the difference between individual and intersubjective solutions, between science as a creative activity and as accumulative knowledge.

of genius are possible; she also alerts us to the fact that an individual can and should accept intuitive certainty even if the proof of it does not (yet) exist. Her presence is counter-balanced by Bernard, who attempts to transform his individual intuition into intersubjective knowledge without involving the kind of proof that such intersubjectivity requires.

In contrast to the poststructuralist view of the relativity of knowledge, Stoppard, like the other externalist realists discussed in section 4.1, holds on to the idea of universal laws. In *Arcadia* mathematical equations, human beings and the turbulence of time all express the same universal patterns of behaviour. But the idea of universals presented in this play is not a reductive threat to the individuality and variety of human existence. Stoppard's characters manage to move with infinite freedom in their finite spaces and to create a dance of intricate thought and feeling from the basic steps provided by universal laws. Like the authors and critics discussed in the previous two sections, Stoppard presents the connection between human minds and physical reality as a function of the chaotic dynamics that rule both mind and reality. The connection is an extension of the self-similar patterning of the universe, and one solution to the age-old dilemma of what counts as knowledge in the arts, in the sciences and in the everyday lives of human beings.

The Attraction between Bodies on Heat

'One of the paradoxes in Stoppard's writing', writes Alice Rayner (1987: 135), 'is that no matter how far the mind ranges with ideas or potentials or possibilities, it finally returns to the inexplicable concreteness of objective physical reality'. Although it is a play fizzing with ideas, *Arcadia* too is a theatrical representation of both physics and physicality. Not only is chaos theory explicitly present in the play, but the characters, buffeted as they are by the forces of mutual attraction and repulsion, embody the chaotic dynamics that affect all living systems. Their physicality is made even more pronounced by the environment within which they exist: by

the room on the stage where the presence of various physical objects is constantly emphasised, and by the garden surrounding the country house, talked about but never seen, which is not actually a natural environment but a succession of representations of nature. In Stoppard's play, reality is not something manufactured by the mind or by language, but an intriguing and beautiful realm which the mind, alternatively aided and hampered by the patterns of nature and nurture, attempts to comprehend.

Thus the physical environment surrounding the characters in *Arcadia* reflects the play's theoretical themes, but at the same time comes across as refreshingly real. The events of two separate eras take place in a single room which remains unaltered on stage through the scene changes. The tangibility of objects is emphasised by the way they mount the schoolroom table in the course of the play, and the way historical documents, like Chater's letters and Thomasina's diagrams, survive on the stage as physical objects from one era to the next, even though people's perception of their meaning may change.[92] Their obstinacy is also emphasised by the way the seemingly innocuous but intractable garden books disprove Bernard's theories.

Another physical system constantly present in the play (though not on stage) is the garden of the Coverlys' manor house. As suggested in section 2.2, Stoppard employs the garden as the playground of ideas concerning classical, romantic and chaotic geometries, but it also plays an important role as the site of discussions concerning the relationship between nature and humanity. Some critics have taken the garden to stand for the natural forces, suggesting, as Demastes (1998: 97-98) does, that the romantic version is an example of nature in its chaotic phase: a system where the initial conditions are set and which is then allowed

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[92] The objects (as well as the garden designs) are also an allusion to one of the play's intertexts: Thomas Love Peacock's *Headlong Hall* (1816), where an assortment of objects, including a quadrant and drawing books, are used to stimulate philosophical discussions among the people gathered at a country house. For this and other intentionally used intertexts see Nadel (2002: 426-430).

to freely run its course. However, as Hannah so clearly points out, all the different gardens are imitations of paintings imitating classical authors (*A* 25), and therefore it would be more accurate to say that they are all representations of various kinds of conceptualisations, and are not natural at all. The Arcadia that Lady Croom sees in her neo-classical garden design attempts to reproduce nature 'as God indented', but in fact it is a representation of nature as the controlled, classical steady state where even the sheep are 'tastefully arranged' (*A* 12). The 'picturesque' design by Noakes, however much it aims to reproduce the 'irregular forms' of nature, also remains a representation, although the process of its creation does produce much disorder: unfinished, muddy lakes, 'mean plantations', and the disrupting noise of the steam pump.

Such representations of an ideal environment act as reminders of two other representations, the classical Arcadia and the Garden of Eden, where it was imagined that humans lived in perfect rapport with their environment. Whatever form the ideal environment takes, the presence of both death (in the form of the references to Poussin's famous painting and Thomasina's death in the fire) and knowledge (Thomasina's realisation of the implications of entropy and chaos, and the modern characters' self-conscious sexuality) opens the closed system of the representation and exiles its inhabitants into reality. Stoppard even toys with the idea of the apple as a symbol associated both with carnal knowledge and, through Newton's famous gravitating fruit, with scientific knowledge. In *Arcadia* an apple, first given as a love token by Gus to Hannah, is left on the table and fed by Septimus to his tortoise before its leaves finally become the catalyst for Thomasina's equations, giving her a brief glimpse of the laws of life before her own cruel expulsion from the garden of Sidley Park.[93]

As Alison Wheatley (2004: 178) suggests, from the very first scene the garden, rather than representing the forces of nature in the play, functions merely as the setting of the truly uncontrollable

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[93] Both the original (London and New York) productions of *Arcadia* underlined this theme by having Poussin's *Spring*, which pictures Eve offering the apple to Adam, painted on the stage curtain (Fleming 2001: 196).

natural force: sexual desire. Septimus's 'carnal embrace' in the gazebo with Mrs. Chater is the first of many references to the unpredictable world of human sexual attraction, where chaotic dynamics rule the day. In both time periods the characters experience confused relationships with each other: in the nineteenth century Thomasina is in love with Septimus, who pines for Lady Croom who is in love with Byron, who has an affair with Mrs Chater, who had a 'perpendicular poke' with Septimus, and all of the male twentieth-century characters desire Hannah, a woman as self-contained as the palindrome of her name. Throughout the play, the element which breaks open the deterministic universe is heat – both as a phenomenon of physics and as a metaphor for human passion. 'Heat cannot of itself pass from one body to a hotter body', says the Second Law of Thermodynamics, and Stoppard makes delightful play both with the suggestive vocabulary and the phenomenon of entropy implied by the law (see 112-118). Thomasina takes explicit note of this connection, pointing out how Mrs Chater, whose affairs have already resulted in two challenges to duel, 'would overthrow the Newtonian system in a weekend' (*A* 84).

In the twentieth-century plot the main force of sexual energy is produced by Hannah and Bernard, with additional confusion caused by both Valentine's and Gus's desire for Hannah, and Chloë's for Bernard. Hannah and Bernard are a couple whose differences, like those between Septimus and Thomasina, can be seen in terms of classicism and romanticism. However, these characters seem to have adopted one attitude as a camouflage for another. Bernard wears his romantic flamboyancy, like his peacock-coloured handkerchief (*A* 16), as a cover for his lack of true feelings. He is interested in Byron as 'an eighteenth-century Rationalist touched by genius' (*A* 60), rather than as a romantic figure. Hannah, on the other hand, seems an ardent classicist, but as Valentine points out, her 'classical reserve is only a mannerism; and neurotic' (*A* 75), and Bernard notes that she can get 'quite sentimental over geometry' (*A* 28). Her book on Caroline Lamb, the woman who made such embarrassingly public love to Byron,

connects Hannah with unfettered passion, even though the book attempts to present Caroline as an intellectual figure (see *A* 60). As Bernard says, it 'takes a romantic to make a heroine of Caroline Lamb' (*A* 63). The modern characters perform a complicated dance of sexual and intellectual repartee which finally does not bring them any closer to each other. The exceptions are Hannah and Gus, whose awkward waltz accompanies the fluid dance of Septimus and Thomasina at the end of the play.

The reason for this unpredictable behaviour of people in a supposedly deterministic universe lies in the complexity and chaos inherent in human beings. Or perhaps, as Chloë thinks, the unexpected behaviour of people results in a non-deterministic universe:

> CHLOË The future is all programmed like a computer – that's a proper theory, isn't it?
>
> VALENTINE The deterministic universe, yes.
>
> CHLOË Right. Because everything including us is just a lot of atoms bouncing off each other like billiard balls [...]. But it doesn't work, does it?
>
> VALENTINE No. It turns out the maths is different.
>
> CHLOË No, it's all because of sex. [...] The universe is deterministic all right, just like Newton said, I mean it's trying to be, but the only thing going wrong is people fancying people who aren't supposed to be in that part of the plan.
>
> VALENTINE Ah. The attraction that Newton left out. All the way back to the apple in the garden. (*A* 73-74)

In this play, human relationships do not work like Newtonian two-body problems but rather like unpredictable and chaotic three-body problems, where the complexities of the mutual gravitational attraction between three equally sized bodies makes it impossible to predict the system's behaviour. In the words of John Gribbin (2004/2005: 14-15), '[t]he equations describing such systems can be written down, but they cannot be solved – they are not integrable and are said to have no analytical solutions'. Where at the opening of the play Thomasina envisions a completely deterministic universe (see p. 153), the conversation between Chloë and Valentine counters such an ideal with the fact that calculating

even the mutual influences between just three objects turns out to be impossible. Despite the determinism of the universe, its dynamics mean that the future can only be known by living it.

By coupling and contrasting physical attraction between humans and the gravitational attraction between physical bodies, Stoppard both connects humans to the material universe and suggests that their individual quirks are real and have an impact on the depersonalised forces of nature. For chaos theory does not reduce its subject matter to a mere collection of random particles, but underlines that any complex system is always more than the sum of its parts. Thus the play suggests that humans share with the universe not only all their molecules and the rules by which they move, but also the particularity of the patterns formed. If such mundane physical phenomena as dripping taps and cream swirling in coffee form harmonious yet unpredictable patterns, then human life, if shaped by the same laws, is also beyond reductive analysis. As Stoppard (as quoted in Fleming 2001: 191) has stated in an interview, for him chaos is a 'powerful metaphor for human behavior' and one which manages to balance the 'determined life' with unpredictability. From this point of view, the mind could be regarded as limited in its building-blocks, but infinite in its capacity for uniqueness. The sensitivity of chaotic dynamics to initial conditions makes such systems unpredictable even though deterministic, as Valentine explains:

> We're better at predicting events at the edge of the galaxy or inside the nucleus of an atom than whether it'll rain on auntie's garden party three Sundays from now. Because the problem turns out to be different. We can't even predict the next drip from a dripping tap when it gets irregular. Each drip sets up the conditions for the next, the smallest variation blows prediction apart, and the weather is unpredictable the same way, will always be unpredictable. When you push the numbers through the computer you can see it on the screen. (*A* 48)

The realisation that simple systems can behave in ways that confound the greatest physicists ends the physicalist dream that all human behaviour is explainable by reductive theories based purely on matter. It also takes away the need for the arts to entrench

themselves and completely separate thought from physical existence. The fact that human beings are made of flesh and blood and exist together with earth, rocks and trees, does not mean that they cannot be creative, unique and unpredictable individuals. This allows Stoppard to embrace the notion of our material existence without falling prey to reductive physicalism.

In addition to being a materialist of sorts, Stoppard, in writing this play, has also made full use of both the conventions of literary realism and realism as a philosophical position. Although it may be strange to consider a playwright as metadramatic and playful as Stoppard as a realist, it is important to note that the argument presented in the previous chapter about realism and metafiction also applies to drama. Ruby Cohn, in *Retreats from Realism in Recent English Drama* (1991) includes Stoppard in her discussion of playwrights who abandon realism, but she explicitly refers to Stoppard's breaking of theatrical conventions rather than to his rejection of realist epistemology. Other critics have, however, made the mistake of taking the use of non-realist technique as a sign of anti-realist epistemology. Mary A. Doll (1993: 118), for example, categorises Stoppard as a 'post-Absurdist' in the sense that he goes 'even further than Absurdists in dispensing with unities of plot, character, and action, together with the illusion of certainty such unities assume'. But although Stoppard's plays have undermined certainties, they have never actually broken the connection to reality. Rather, they have only momentarily shaken the audience's trust in the rationality of the world before reinstating it. Therefore, although Stoppard destabilises the 'illusion of certainty', he never abandons the representational quality of drama. His characters are unitary: however confused about their names, even Rosencrantz and Guildenstern remain distinguishable characters throughout the play that bears their names. Similarly, as I pointed out in my discussion of *Arcadia*'s structure, the fluctuating time-frames never actually break the realist frame (in the philosophical sense), they merely exist in superposition for a dramatic effect.

In Stoppard's play everything is interlinked: the two time levels, the emotions of the characters and their research projects, their lives and the shape of gardens. In his presentation of the affinities between physics and human behaviour, Stoppard also forges a connection between people and the physical world they live in, and rejects the idea that human existence is bounded by language and therefore has no real contact to other human beings or to material objects. At the same time, the link between the mental and the physical provides the justification for the various kinds of truths that the characters pursue, be they mathematical, emotional or historical.

'It's Wanting to Know That Makes Us Matter'

Far from being uncaring intertextual play, Stoppard's drama has always been, as Clive James saw as far back as 1975, informed by '*Einfühlung* – the intellectual love for the objects of experience' (James 1975: 76). What James refers to is the empathetic connection between mind and object, that is, the way in which Stoppard feels his way into his subject matter. In *Arcadia* Stoppard not only emphasises the existence of a physical reality, but also offers chaos theory as a way of connecting thought with that reality through the self-similar connections between different organisational levels of the universe. Like the other externalist realist critics and authors, Stoppard exemplifies in his writing a cosmological interest, and like Jorie Graham, he conceptualises the mind's contact with reality as an embodied experience.

Through his use of chaos theory, Stoppard underlines the fact that the complexity of physical reality is such that we have to accept that we know much less about the way it all works than we think we do. In the play Valentine describes the state of physics before the arrival of chaos theory:

> People were talking about the end of physics. Relativity and quantum looked as if they were going to clean out the whole problem between them. A theory of everything. But they only explained the very big and the very small. The universe, the elementary par-

ticles. The ordinary-sized stuff which is our lives, the things people write poetry about – clouds – daffodils – waterfalls – and what happens in a cup of coffee when the cream goes in – these things are full of mystery, as mysterious to us as the heavens were to the Greeks. (*A* 48)

Valentine's own project involves searching for the algorithm that rules the history of the grouse population of his ancestral lands. But discovering the true algorithm in the middle of the noisy data is too complex a task, since it is impossible for Valentine to track down all the variables involved. 'Real data is messy', he laments.

It's all very, very noisy out there. Very hard to spot the tune. Like a piano in the next room, it's playing our song, but unfortunately it's out of whack, some of the strings are missing, and the pianist is tone deaf and drunk – I mean, the *noise*! (*A* 46)

There are similar difficulties in the various efforts by the characters to gain information and communicate it to each other: letters get lost, statements are misinterpreted and the noise of the steam engine in the nineteenth-century garden drives the lady of the house to distraction. If predicting the future is impossible because of the complexities displayed in the dynamics of systems with multiple variables, interpreting the past is hampered by the presence of noise in the data.

Although a few critics have been distracted by the presence of these epistemological difficulties (e.g. Boireau 1997, Doll 1993 and Peter 1993), it is clear that however difficult the search for knowledge, according to Stoppard it is still a valuable endeavour. For instance, rather than seeing Stoppard's extensive word-play as a sign of 'surface dazzle', as others have (e.g. Jenkins 1993), Clive James (1975) is adamant that even the punning is a sign of a desire for a more useful, a more extensive clarity. In comparing Stoppard's works to the general theory of relativity and to the way the paths of vectors converge in space-time James (1975: 72) suggests that Stoppard's interest is not focused on the fact that words can mean anything, but on the ambiguities formed when several texts and contexts cross each others' paths in one word: 'It isn't helpful to call such effects dazzling, since they are not meant to dazzle

nor be effects' but 'devices by which you see further'. In chaos theory Stoppard has found a touchstone which takes the theories of physical existence from the galactic or quantum levels – levels of reality which most people understand only as distant abstractions at best – to the level of everyday natural phenomena on a human scale. The results of his intense examination of the nature of reality can be dizzying, and cause the simultaneous fear and fascination with which his characters stare at infinity. But, especially in the later plays, the fascination does win out. Similarly, almost thirty years after James, Daniel Jernigan (2003) makes the point that Stoppard is still much too interested in trying to know, and too little interested in the ideological underpinnings of constructed knowledge to count as a true postmodernist. Even though he is still 'completely serious about frivolity and stylishness as ways to make ideas fly' (Jenkins 1987: xi), it is the ideas that finally count, not the style alone. Thus it is difficult to think how a playwright whose work is so clearly based on extensive research on issues ranging from physics to philosophy could be viewed as anything other than intensely curious about the world he delves into.

In *Arcadia* the necessity of curiosity is voiced by Valentine, who waxes lyrical on the subject of what science has yet to discover, now that chaos theory has proven some of the old assumptions wrong:

> It makes me so happy. To be at the beginning again, knowing almost nothing. [...] A door like this has cracked open five or six times since we got up on our hind legs. It's the best possible time to be alive, when almost everything you thought you knew is wrong. (*A* 47-48)

Although Valentine is excited about chaos theory proving many old scientific assumptions wrong, such enthusiasm for the unknown stems not from enjoyment of uncertainty as such, but from the fact that there is much more to know than one previously thought. This enthusiasm for curiosity is shared by Hannah, the rational sceptic set against Bernard's impetuous certainty. Where Bernard is dead sure about Byron fighting a duel at Sidley

Park, Hannah develops a gut instinct about the identity of the nineteenth-century garden's resident hermit. Her intuition ends up being correct, mainly because she is more genuinely interested in knowledge. Rather than sharing Bernard's aspiration to the title of 'Media Don' (*A* 56), she is passionate about finding things out, not about being famous for finding: 'It's wanting to know that makes us matter. Otherwise we're going out the way we came in' (*A* 75). Ira Nadel (2002: 430) points out a 'possible pun' in Hannah's line, suggesting that not only does 'wanting to know' make human life meaningful but it is also the way in which we acknowledge our connectedness to the rest of 'matter'. We are physical beings as well as mental ones, and wanting to understand the material universe is a valuable endeavour that can be achieved in a myriad of ways.

Imagination and Chaos

The ways in which human beings try to understand the world include both investigation and representation. The cold facts of scientific inquiry may show that universal laws apply in the lives of individual human beings, but at the same time meaning may be discovered in the unexpected beauty of the patterns of those lives. On the other hand, the world becomes a cold and inhospitable place if scientific knowledge alone is used to explain it. The answers we gain from science may leave us 'alone, on an empty shore' (*A* 94), but even then we can dance.

Mary A. Doll (1993) is one of the critics who take the presence of epistemological problems in *Arcadia* to mean that the main purpose of the play is to enhance a feeling of uncertainty in the audience. According to Doll (1993: 117-118), Stoppard presents any certainty about reality 'as an arrogant attitude inherited from the postures of logical positivism and classical science'. Rodney Simard (1984: 51), on the other hand, argues that Stoppard insists on logic and reason but only to show that the logical rules of causality themselves produce the absurdity: 'His comedy arises largely from logically extending his action one step further

than it exists in objective reality'. But it is important to note that even though both Doll and Simard view absurdity and the critique of strict logic as the complete picture, such aspects are counterbalanced by Stoppard's conviction that both the intersubjective project of science and the imaginative leaps of individuals can get to know the world.

One of the most important themes in *Arcadia* is the debate over what counts as knowledge, and whether the inevitable lack of absolute proof should be a source of hope or despair. Despite the problems and confusions, there are a number of epistemologically optimistic elements in *Arcadia*. At the very end Hannah receives strong evidence of the identity of the hermit, Bernard's theory of Byron's duel is proven wrong by a small detail mentioned in a garden book, and Thomasina's seemingly pointless fractal equations are shown to be meaningful nearly two centuries later. Stoppard uses chaos theory not only to describe people as both determined *and* free, but also to explore ways of accepting the impossibility of undeniable proof without falling into epistemological relativism.

For most of his career, Stoppard has been questioning the logic that pronounces knowledge worthless for being fallible, thus expressing the same dissatisfaction with complete reliance on axiomatic logic that was expressed by Paulson, Toulmin and Paisley Livingston in section 4.1. While actively criticising scientism and epistemologies built on absolutes, he has still, in both *Hapgood* and *Arcadia*, turned to physics for a heuristic on which to build knowledge that would be trustworthy in practice, though not resting on absolute axioms. Quantum mechanics proved a difficult subject for the audience to grasp and *Hapgood* suffers from being overtly complex, but in *Arcadia* Stoppard finds a firmer ground in chaos theory and creates a system of intuitive knowledge based upon the self-similar connection between mind and nature. Even while he reminds us that the world is too complex for simple categorisation, Stoppard also shows that the universal chaotic dynamics provides an intriguing way of connecting the human mind to reality, of forming a conduit by which we could have intuitive

knowledge about our environment. Through his characters and through the implications of chaos theory Stoppard explores the differences in what it means to know, to have intuitive certainty, and to leap to conclusions.

In *Arcadia* the argument between classical and romantic attitudes extends to conceptualisations of science and art, and to the wider questions of knowledge and creativity. Stoppard's depiction of the classical and romantic gardens brings out the differences between thought structures based on order and those based on disorder (see 2.2). However, the separation of the two conceptual structures does not result in a simplistic division between classical science and romantic literature, nor does it suggest that science involves only facts and literature only creativity. What sets the two otherwise intersecting forms of knowledge apart is the nature of proof. Where the individual genius of both scientists and artists may light upon the truth, in order to become knowledge, scientific innovations must be intersubjectively proven, whereas artistically mediated knowledge speaks from one individual to another in a way that cannot be replicated.

Thus scientific inquiry is revealed in the play as a fractal algorithm in which you feed the new information back into what you already know and try to see where the new result fits on the map, whether it changes the overall pattern or not. As Valentine points out about computer-generated fractals, you 'never know where to expect the next dot' (*A* 47), but eventually you (or generations of researchers after you) begin to see a pattern in the data. On the other hand, as Antor (1998) has pointed out, both the implications of Thomasina's discoveries and her joking note in the margin of her mathematics primer emphasise the fact that sometimes knowledge is not intersubjective but consists of patterns we have made for ourselves in order to make sense of the world. These patterns, Antor (1998: 353) suggests, arise from our 'anthropological set-up' and do no harm as long as their status as heuristic devices is kept in mind. It is clear, however, that the patterns discovered by individual intuition in *Arcadia* are not meant to be seen

as temporary 'epistemological crutches', but are, instead, the other side of the coin of scientific, intersubjective knowledge.

The emphasis chaos theory lays on the recurring patterns which arise from the infinite complexity of our universe gives Stoppard a fitting metaphor for the intuitive connection between the knowing mind and reality. Werner Kriegelstein (1993: 99) has suggested that being part of a complex, yet harmonious and self-organising universe 'will allow us to draw conclusions from a totality of simultaneous impressions rather than through step by step "logical thinking"'. Similarly, in *Arcadia* chaos theory is used to suggest that from the shared dynamics between mind and world arises intuitive knowledge. As parts of a self-similar universe, the characters' imaginations reflect the chaotic dynamics, helping them to recognise aspects of the world in the same way they recognise aspects of themselves. In this Bernard's declaration about the power of poetry and self-knowledge (*A* 61) turns out to be true in a different way than he himself realises. What the self-similarity of the universe suggests is that you cannot understand the universe without understanding yourself, nor can you understand yourself without understanding the universe.

It is clear to anyone familiar with the history of science that intuitive leaps are not the exclusive property of poets. Scientific genius also depends on the ability to see directly into the heart of the matter, past the slow steps normally required for acquiring knowledge. Even though the general rule of scientific development is, as Valentine says, that you 'cannot open a door till there is a house', Hannah points out that the ability to take shortcuts is exactly what genius is (*A* 79). Such is the gift of Thomasina, whose mathematical talent goes beyond the methods of calculation available to her. 'She saw what things meant, way ahead, like seeing a picture', admits Valentine (*A* 93). Thus Stoppard dismantles the stereotypical idea of artists as intuitive and scientists as rational, and simultaneously collapses the distinction between their purviews. Imaginative leaps are not a relativistic opposite to logic, but a necessary part of our relation to the world, whether that relation is expressed in terms of science or literature. Thus the

world of imagination is not the exclusive playground of poets, nor is reality reached solely by scientific means.

The most evident of the intuitive connections in the play is the one the twentieth-century humanist scholars have with the events of the past. Bernard claims to feel this particularly strongly:

> Gut instinct. The part of you which doesn't reason. The certainty for which there is no back-reference. Because time is reversed. Tock, tick goes the universe and then recovers itself, but it was enough, you were in there and you bloody *know*. (*A* 50).

Somehow Bernard's intuition is like the reversal of time, a moment when he slips from one century to another to be present at the time of the events he is studying. History in *Arcadia* is, not least because of the structure of the play, a series of self-similar loops, where intuition can sometimes leap from one orbit to another, defying the second law of thermodynamics and time's arrow.

But even if Bernard's failure gives support to the notion that the past is irrecoverable, Stoppard plays with the possibility of going back in time. The presence of successful temporal loops is suggested, in particular, by the character of Gus, the shy, speechless twentieth-century teenager who has such a knack for discovering just what the other characters spend ages trying to grasp. He points garden historians to the exact spot of the foundations of an old boathouse (*A* 48), and he passes on to Hannah the evidence she needs to show that Septimus was (in all likelihood) the Sidley hermit (*A* 96-97). Played by the only actor to have roles both in the nineteenth and the twentieth centuries, Gus doubles in the past as Thomasina's older brother, Lord Augustus. His presence is almost like a physical conduit between one era and the next – an effect strengthened by the moments of confusion in the audience over when he is Lord Augustus, and when Gus in Regency dress. The impossibility of reversing time's arrow is symbolically overturned by the final scene of the play, where the dance of Hannah and Gus reflects and recreates the first and last waltz of Thomasina and Septimus.

In terms of intuitive knoweledge there are no signs of Stoppard prioritising one or the other of the Two Cultures. Where Richard Corballis (1984: 15) argues that 'in all Stoppard's work an abstract, artificial view of the world ("A") is pitted against the flux of reality ("B"), and the audience is invited to eschew the "clockwork" of the former in favour of the "mystery" of the latter', I would say that Stoppard takes the abstract as an essential part of appreciating the flux. Corballis is on the right track in recognising the critique of abstract logic in Stoppard's work, but embraces too readily the idea that Stoppard abandons the world of scientific discourse in favour of the experience of the mysteries of reality.

The question of whether science and art both count as knowledge is another source of debate between Valentine and Bernard. On the one hand, the most valuable aspect of science is its ability to organise our perceptions of reality into a system which helps us weed out untruth, however attractive. On the other, poetry emphasises our innate ability to make intuitive leaps which bypass the slow, methodical rules of science. In following Thomasina's research even Valentine learns that sometimes it is possible to understand a larger pattern of interactions without having knowledge of the system's basic elements. But for the mathematician, the reason for striving for knowledge is always the knowledge itself, which exists apart from the lives and personalities of the people involved in its creation. 'It's like arguing who got there first with the calculus', he declares. 'The English say Newton, the Germans say Leibnitz [sic]. But it doesn't *matter*. Personalities. What matters is the calculus. Scientific progress. Knowledge' (*A* 60-61). As the counterbalance to this cumulative view of the human endeavour Stoppard presents the anachronism of Thomasina's discoveries (Clayton 2000: 205). Although her thinking was left in a *cul-de-sac* of scientific discovery, her ideas have a value that depends on their connection to her singular personality. At the end of the play the audience would be hard pressed to claim that personalities did not matter, and that Thomasina's death was of no consequence since her inventions were rediscovered by later generations.

The play consistently balances these two aspects of knowledge with the help of deterministic chaos. For Bernard, the human dimension is the only one that counts: 'I can expand my universe without you', he snaps to Valentine and quotes Byron's 'She Walks in Beauty' (*A* 61). Valentine, for his part, has to admit the inherent impossibility of his attempt to define the actual chain of cause and effect in the fluctuations of grouse populations. On the other hand, the surprising harmonies of the universe connect one set of characters with another, making possible the transmission of knowledge through the intervening decades. The two true geniuses of the play are Thomasina and Gus, one able to see into the future of mathematics and physics, the other able to see back into the past lives of the Coverly manor. Mathematics is a field where individual intuition is vital for the creation of new solutions, but even though Thomasina may have known she was right, her discoveries could not be integrated into the larger system of mathematics until much later. In historiography too the gut feeling of one person may be either a personal truth or an intersubjective one, depending on the kind of evidence it is possible to gather. According to Stoppard (as quoted in Fleming 2001: 207), Gus is an embodiment of those elements in the universe which are not mechanistic, those aspects which we know are there, even though we have no rational, scientific way of explaining them. The boy is an embodiment of intuitive genius, of the idea that chaos theory might explain why the correct conclusion may be reached through subjective certainty even when intersubjective proof is lacking.

Hersh Zeifman (1990: 179) has pointed out that though Stoppard's plays are indebted to Beckett, they are fundamentally optimistic about ontology in that they evince a heartfelt belief that things do exist even though their existence cannot be logically proven. Between this optimistic subtext and the use of absurdist techniques Stoppard has created a tension from which arises post-absurdist, or according to Demastes (1998), 'chaotics' theatre. 'On the surface, the absurdist vision originally "inherited" from Beckett is brilliantly sustained, but *under* the surface that vision is continually being eroded and sabotaged', Zeifman (1990: 179) con-

cludes. In my opinion, Clive James (1975: 75-76) epitomises this duality best in suggesting that Stoppard relies on intuitive certainties even while he deconstructs the logic behind them:

> And if the whole vaultingly clever enterprise turned out to be merely intuitive – well, what is so mere about that? It might be only in Stoppard's enchanted playground that the majestic inevitabilities of General Relativity can be reconciled with the Uncertainty Principle or quantum physics, but Einstein's life-long search for the Unified Field was the same game, and *he* believed in intuition.

In *Arcadia* Stoppard pulls in all the different strands of these issues, creating a play in which the idea of deterministic chaos is used to enliven questions of knowledge. The characters are shown as embodied beings in a world of deterministic chaos, attempting to understand their environment and themselves by both imaginative and rational means. The presence of mistakes and failures in the characters' various quests for knowledge serves as a reminder that certainty arrived at through an imaginative leap is by no means infallible.

The resounding failure of Bernard's intuition to alight on the truth about who exactly shot which hare and who challenged whom to a duel may for some members of the audience overshadow the quiet successes of the other modern characters. But they do make genuine discoveries: Hannah by uncovering the fate of Septimus Hodge, and Valentine by unearthing the meaning of Thomasina's equations. These characters are also the ones who passionately believe in the importance of finding out the true nature of things. This is particularly true of Hannah, the self-declared enemy of chaos in art and life, who in the course of the play accepts both Gus's apple and his invitation to dance, learning to trust her feelings and let her imagination guide her. However wrong Bernard turns out to be, his mistaken intuition is counterbalanced by Hannah's correct gut feeling about Septimus being the hermit. 'You don't *know* that', Valentine warns her, but Hannah is adamant: 'Oh, but I do. I do. Somewhere there will be *something* ... if only I can find it' (*A* 66). What is more, as the structure

of the play intersperses action from one era between the events of another, the audience is first put in the position of the arbitrator of the different intuitive certainties, and is then led, along with Hannah, to the intuitive conclusion that the hermit *must* be Septimus (Martyniuk 2004).

The arguments between Bernard and Valentine over whether cosmological models should be accepted because they are true or because they suit a particular temperament, are an echo of the epistemological discussions on the position of the natural sciences after Kuhnian paradigm shifts and social constructivism positioned them as just one of many alternative ways of presenting reality. Stoppard (1993/1994: 268) comments in an interview on the reaction against scientism around the year 1800, when Blake, Wordsworth and Coleridge were resisting the idea that science might soon find out all the answers: 'The sense, or illusion, that science is doing exactly that seems to accompany every age, and creates an opposing force'. The new angle that chaos theory has given Stoppard is that science may reveal important truths about the world and about our relation to it, and yet at the same time bring out new mysteries that give our lives even greater individual resonance than before.

In his article marking the opening night of *Arcadia*, Michael Billington (1993: 2) identifies the search for a system of post-Christian morality as the core of Stoppard's writing career, and describes *Rosencrantz and Guildenstern Are Dead* as 'a play about the danger of living in a society that dismisses God as a logical impossibility and moral absolutes as unprovable'. A similar warning can be seen in *Arcadia*: time and time again in the play rigidly logical processes are shown to be erroneous because, as chaos theory states, all the variables affecting the final outcome can never be known. Many critics have also latched on to Stoppard's (1974/1994: 65) comment that his plays 'are a lot to do with the fact that *I just don't know*', and have interpreted this as an admission of his own uncertainty. But the evidence of his plays, as well as many other comments made by him in interviews, suggest that rather than being a resolute relativist he is merely accepting his

own lack of proof and emphasising the difference between two kinds of knowledge: the kind reached through logical proofs and the kind grasped by intuition. In this way Stoppard's own need to avoid endorsing any specific point of view in his plays can be explained not as embracing relativism, but as a way of bypassing such logical arguments which suggest that true knowledge about mind-independent reality is an impossibility. The two aspects of knowing, intersubjective science and individual imagination are reiterated on different levels of *Arcadia* and result in a blend in which Lightman's serene science and the 'exquisite contradictions' of literature are irrevocably stirred together.

Conclusion: Science and Story-Telling

> Looking back at the twentieth century, historians will speak of it as the Century of Representation: a time when, in all fields of art, thought, literature, and science, people considered, or reconsidered, the place of language in human life, and the basis on which our reliance on it rests.
>
> Stephen Toulmin, *Return to Reason*

In Greg Egan's short story 'Luminous' (1995/1998) two students of mathematics discover a contradiction in the axioms of number theory, a defect which turns out to be a fractal border between traditional mathematics and a kind of parallel universe of incompatible mathematical theorems. In order to stop an unscrupulous financial company from exploiting the discovery, they attempt to erase the incompatible mathematics by calculating proofs for the theorems occupying the fractal border so that the cascade of theorems would finally collapse the defect. What they discover is that the border is defended by some being whose reality depends on the kind of mathematics that in the world of the story is purely abstract. The students' attempt boils down to trying to define mathematics as a system completely free of self-contradiction, one

that covers all of reality and is infallible in its ability to tell the difference between truth and falsehood. The story ends with the fractal border reinstated and the world facing the learning process of letting go of absolute definition and embracing the contradictions 'between the exotic and the mundane, the pragmatic and the Platonic, the visible and the invisible' (Egan 1995/1998: 88). In this story chaos theory offers alternatives to the binary opposition between knowing nothing and knowing everything, between complete relativity and absolute definition.

In this chapter I have argued that the authors discussed aim to combine imaginative abstractions with a strong sense of the physical reality of things. They portray physical reality as the other, as the opposite of the human faculty of imagination, but also suggest that mind and reality obey the same basic rules and therefore that the dynamics of nature are graspable to the human mind and representable in language. These writings by both literary theorists and authors build a connection between literature and reality, and chaos theory plays an important part both in the formation and the expression of this connection.

At the end of *Chaos Bound* Hayles (1990: 292-293) puts her finger on the crucial difference between the scientists and the literary interpreters of chaos she examines. She notes how Gleick's book in particular brings across the 'sense of wonder' the scientists feel towards the systems they study. 'Although they do not put it this way', she writes,

> they intimate that chaos has given them a sense of being in touch with the Lacanian real. [...] They see it rescuing postmodernism from the prefix that positions us in 'always already'. They take chaos as demonstrating that there is something more than novelty, something other than the precession of simulacra.

Opposing this view is the postmodern dialectic, which Hayles (1990: 293) thinks complicates the 'innocence of chaos' by showing that chaos theory itself is created by structures of power: 'When theory, self, and culture are caught in the postmodern loop, the construction of chaos cannot be unambiguous, because it derives from and feeds into the same forces that made us long

for escape'. It is precisely this epistemological difference between innocent, potentially repressive scientific chaos and its sceptical, postmodern version that appears most strongly in most of the previous examinations of chaos theory in literature. However, my argument is that a sense of wonder about the real is far from absent in the literary interpretations of chaos, as the analyses of works by Stoppard, Graham and others show. This group of authors and theorists I have termed externalist realists in recognition of their interest in the possibilities of representation of an external reality. While they accept that individual perception, ideology and a myriad of other cultural factors will always influence the way reality is comprehended, externalist realists do not abandon the attempt at reaching reality as objectively as possible, and they furthermore suggest that such an attempt is a peculiarly human activity. The order seemingly imposed on chaotic flux may actually match an order that already exists in reality, due to the self-similarity of both the universe and the human mind.

As was the case with literary form and the concept of identity, chaos theory approaches to these issues do not exist in a vacuum. In terms of the self-similarity of various structures, for instance, there is a strong resemblance between externalist realism and the theories of iconicity, which have received much attention in literary studies in recent years, especially since the publication of Max Nänny and Olga Fischer's collection *Form Miming Meaning: Iconicity in Language and Literature* (1999). In that volume, Simon J. Alderson (1999: 110) refers to the definition of iconicity in *Dictionary of Stylistics*: 'literature "can be regarded as iconic in the broad sense that its FORM may strive to IMITATE in various ways the reality it presents"'. While scholars making use of chaos theory do not refer to iconicity and employ different terms to describe the structures they analyse, both approaches seem to be looking for an answer to the problem of how to make the discussion of literary form relevant to things other than just the individual work or some generic conventions.[94] However, where the contempo-

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[94] For a discussion of diagrammatic iconicity specifically in the context of literature and science see Batt (2007).

rary theories of iconic form in literature tend to concentrate on drawing parallels between the structures of literary narratives and the structures of human perceptions of the world (Alderson 1999: 119), many scholars drawing on chaos theory are suggesting a link between literary and actual physical structures. Literature, they suggest, is not chaotic because in it authors represent the chaos they perceive, but because that's the way the universe, literature included, functions. This dynamic conceptualisation of the resemblance between literature and reality is itself akin to the arguments presented in biosemiotics, for example in Wendy Wheeler's *The Whole Creature* (2006), where emergent complexity is at the heart of both natural and cultural systems, and both are seen in terms of semiotic processes. While biosemiotics itself is still struggling to understand the differences between mimesis and mimicry, between intentional resemblance and unconscious likeness, it offers an interesting parallel to externalist realism in literary studies.

A second major topic of this chapter has been representation, in particular the ways in which the knowledge transferred by the natural sciences differs from literary representation. Both Graham and Stoppard evidently think that literature can be a source of knowledge and, furthermore, they refuse the romantic division between embodied art and abstract science. Adelaide Morris (2006: 151) has called Jorie Graham's use of the natural sciences as 'thinking not just *about* but *through* a scientific problem'. At the same time Graham always thinks through the body, thus joining in her poetry not only science with art but also embodied science and abstract art. What she attempts to think about through chaos theory is the difference between observation and appropriation, between the object as it is and the object perceived, and she depicts an embodied knowledge which feels like a dynamic process between mind and reality, even when it seems impossible to define a reality separate from the mind.

Stoppard too extends the field of phenomena covered by chaos theory from the physical ones science is prepared to describe, from 'the things people write poetry about' (*A* 48) to poetry itself, and to issues of truth and knowledge. Small incidents in

the past can have vital consequences in the future, and are often misinterpreted by those trying to find out what really happened. In *Arcadia* we find uncertainty over what Fermat really meant by his note, Thomasina's humorous doodle mistaken for the 'only known likeness of the Sidley hermit' (*A* 25), and, of course, Bernard's failed theory about Byron's duel, based on a chain of mistaken inferences based on incomplete evidence. But the play is also a story of discoveries, mathematical, emotional and historical. In its presentation of intuitive knowledge, *Arcadia* reminds us that not everything that is true can be proven. '[T]he essential truths', Stoppard (as quoted in Delaney 1990: 1) says, 'are much foggier things which we recognise instinctively rather than analyse and establish by demonstrative proof'.

One suggestion concerning the directions of future research is implied in the work of Patricia Waugh (2004), who critiques the expansion of purely materialist explanatory models into the understanding of human existence, and advocates a revaluation of the intuited, subjective perspective to a work of art. Waugh not only criticises the 'reassuring' condition of postmodern uncertainty and calls for a way to re-engage the 'scientific impulse' of structuralism with the human condition, but she also emphasises that the human condition must be understood not so much in terms of material universals but in terms of the individual's experience of those universals (Waugh 1999: 59). She goes on to maintain that 'if knowledge is conceived wholly within the paradigm of scientific materialism, then knowledge becomes an entirely third person affair and experience, what it feels like on the inside, is invalidated as knowledge' (Waugh 2004: 71). In *Arcadia* a return to subjective experience is connected both to the embodied feeling of physical reality and to the abstract knowledge produced by the natural sciences about that reality. Such a resurfacing of the subjective, phenomenological perspective seems intriguing and enriching, especially if connected with the latest research on embodied experience provided by the cognitive sciences.

Finally, if the twentieth century is, as Stephen Toulmin suggests in the epigraph of this section, the 'Century of Representa-

tion' because of the humanities' increasing focus on language, the early twenty-first century has taken that focus a step further by emphasising the crucial differences between the concepts of representation and reproduction. If literature merely imitates reality it would cease to have any epistemological value in its own right, and therefore the rehabilitation of mimesis in the sense of representation in discussions concerning the epistemological value of literature is of central importance.

Conclusion

> If knowledge isn't self-knowledge it isn't doing
> much, mate.
> > Bernard in Tom Stoppard's *Arcadia*

> Something has been sold to get here, something of
> mine, something perhaps | very precious | to me,
> an heirloom, an inheritance [...].
> > Jorie Graham, 'Disenchantment'

> But let's never imagine that by explaining things we
> explain them *away*.
> > John Barth, *Once Upon a Time*

The humanist perspective on chaos theory outlined here seeks to understand and describe the ways in which scientific knowledge of a non-human universe can be understood as part of human self-knowledge. The path taken to such a position winds through the belief that knowledge in the humanities has to be related to human beings, but also through the notion that if the humanities lose sight of the knowledge provided by the natural sciences they lose something essential to their own project. My final epigraphs indicate three important landmarks on that path. Where Stoppard's literary historian rather aggressively defends the value of human-centred research as opposed to the dehumanised sciences, the few lines from Graham's poem suggest that the humanities' freedom from reductive materialist approaches may have been bought for a price that she at least is loath to pay. In their writings, the three authors who form the backbone to my presentation of the humanist perspective are renegotiating the deal between literature and science. Stoppard, Barth and Graham present in their works a material universe of complex, yet perceivable forms, and their writings reflect the pleasure generated by human curiosity about the shape and behaviour of those forms, a curiosity that expresses itself in both science and art. However, such

pleasure is not just cognitive but includes an aesthetic dimension as well. As Barth points out in the third epigraph, even while science, philosophy and literary theory may develop explanations for the universe and for mankind's place in it, such explanations will never be final nor will they end the human need to create non-scientific representations. Disenchantment in this context is demystification, not devaluation. Thus, from the humanist perspective, the universe in all its chaos and the multitudes of ways in which the texture of reality can be represented in literature will retain their beauty and fascination, however detailed the explanations given of their basic processes.

The focus in this study has been on the links between literature and science at the turn of the twenty-first century. The relation between chaos theory and literature has turned out to be a complex combination of more or less direct influence (in both directions), misunderstood technicalities (again, in both directions) and illuminating reinterpretations of heuristic metaphors. As I pointed out in the Introduction, my aim has been to observe this particular niche of interdisciplinary research in order to discover why chaos theory has appealed to so many authors and critics and why it has been understood in such different ways. As such, this study presents an encounter between rather than an interdisciplinary merging of literature and chaos theory. What I have delineated here is one approach a literary scholar can take towards scientific knowledge which respects that knowledge as an 'expert witness' and yet focuses on the special competence of the humanities as commentators on meaning and value in culture.

'The primary function of a literature-science critic', writes Daniel Cordle (1999: 176), 'is to describe the intersection of literature and science in the culture'. This I have attempted to do not only by presenting readings of works of fiction, poetry and drama where the concepts developed by chaos theory appear but also by examining the use of those concepts in literary scholarship. I have shown that chaos theory is deeply involved in redefining notions central to literary studies, such as literary form, authorial identity and the relation of literature to reality. Although the direct appli-

cability of chaos theory to such issues is understandably limited, it is clear that the concepts and metaphors adopted from the sciences have played a role in furthering the discussion in the field of literature.

Furthermore, theoretical disagreements within the humanities, in particular literary studies, form another dimension to the conceptual graph I have been tracing. The intersection I have described is not only between the sciences and the humanities, but also between the poststructuralist and the humanist perspectives within the humanities. Like Cordle himself (1999: 75-105), most literary theorists have discussed chaos theory in terms of both postmodern cultural forms and poststructuralist literary theory. While it is true that postmodernism has had a central role in the ways in which chaos theory has been adopted into non-scientific culture in general and literary studies in particular, I have attempted to show that poststructuralism has not been the only theoretical framework involved. Interpretations of chaos theory have also been influenced by what I have termed humanist conceptualisations, particularly in connection with the four major issues discussed above: appreciating the role of scientific knowledge in culture, conceptualising the literary work as a semi-autonomous and meaningful entity, seeing human identity as coherence rather than dissolution, and believing that physical reality and embodiment can be represented by literature.

Now I would like to turn from the synchronic picture I have drawn of the relations between literature, chaos theory and the humanist perspective to make some brief diachronic connections between humanism in the late twentieth and early twenty-first century and romanticism in the early nineteenth century. As I pointed out in chapter 2, the humanist conceptualisation of literary form as 'artificially autonomous' (Paulson 1988: 135) bears many of the characteristics of the organic metaphors of romanticism. The emphasis on life-like patterns instead of Euclidian geometry – on the form of the rose instead of just pyramids and cones in Thomasina's terms (*A* 37, 84) – was prominent in romantic natural philosophy, for example in the work of the chemist

Sir Humphry Davy (Lawrence 1990: 213). Similarly, for romanticism Man, not God is the prime mover in the universe (Cunningham and Jardine 1990: 1), and the humanist perspective, by opposing the impersonal networks of ideology and language, also focuses on the human agent in the study of culture. It is clear that for instance the notion of coherent authorship on which Barth's authorial identity partly relies is itself a notion deriving from the romantic era. Such similarities go to show how the humanist perspective draws on cultural tradition, in particular on the period before the disillusionment inherent in twentieth-century modernism.

However, there are also important differences between romanticism and the kind of humanism discussed in this study. One major point of disagreement is in the attitudes to materialism. Where romantic thinkers – including many of the natural scientists of the time – supported vitalism and tended to regard life and consciousness as autonomous forces (Knight 1990: 19-21), the humanist perspective relies on emergence as the principle explaining how matter can produce both life and consciousness. This difference in attitudes towards materialism has important consequences with respect to the ways in which romanticism and contemporary humanism view the role of science. Where Shelley, for instance, took science to stand for reductionism and oppressive determinism (Paulson 1988: 13), the humanist interpretations of chaos theory embrace the natural sciences as a valuable source of knowledge – to some extent even as a valid source of self-knowledge.

In addition to taking a more appreciative view of the natural sciences than romanticism did, contemporary humanism is naturally tied to a very different historical moment and carries the marks of the poststructuralist critique of realist representation. The relations between thought, language and reality have revealed levels of complexity that romantic theory of art did not yet conceptualise, but which all contemporary approaches have to take into account, at least to the extent that postmodern literary forms are related to them. Even if the humanist perspective does not take metafictional elements in literature as automatically disman-

tling its representation of reality, authors such as Barth are nevertheless clearly indebted to postmodern literary techniques and employ those techniques fully aware of the complexities involved.

Such similarities and differences can be further traced in the arguments presented in the chapters above. First of all, chaos theory adaptations illuminated the different ways in which literary scholarship has conceptualised science, and, conversely, those conceptualisations were shown to reflect the scholars' understanding of the nature of interdisciplinary research. I argued that while many poststructuralist adaptations of chaos theory see science in terms of either culturally determined activity or all-encompassing textuality, the humanist approach tends either to limit itself to the analysis of rhetoric or to take up the knowledge science has produced and use it as a metaphor in order to rethink issues within its own purview. Especially when engaging the sciences as conceptual metaphors for cultural issues the humanist perspective shows an openness to scientific ideas that separates it from both romanticism and the more sceptical branches of postmodern theory.

On the other hand, the humanist perspective's focus on coherent identities and acting agents presents a point of contact with romanticism. By conceptualising identity through chaos theory it is possible to view it simultaneously in terms of complexity and coherence, and to re-engage literary theory with human agency. John Barth's authorial identity was shown to be constructed as an entity that grows and changes from book to book but which, although a textual construct, is a recognisable and undeniable, almost bodily presence.

While such notions cover different sides of the subject/object dichotomy, yet another way to focus on it is the conceptual complex of perception and representation. I have suggested that pattern for many scholars and authors is inherently more interesting than the kind of pervasive disorder commonly signified by the term chaos. Chaos theory has been an inspiration to the humanist perspective of Barth, Stoppard and Graham, all authors who are specifically interested in understanding the behaviour of patterns in literature. In this they differ from those as-

pects of romanticism which emphasised the powers of disorder over the pervasive and ordering patterns of classicism.

It is also important to add that there is nothing inhuman or mechanistic about this love of abstract pattern. Abstraction need not denote wilfully difficult or be opposed to lived reality, but it can refer to shapes both invented and discovered by human imagination in its observation of reality. From this perspective art, humanist research and the natural sciences are all involved in mimesis, understood as the dual process of discovery and invention. Thus attempting to comprehend or even just experience the abstract, the non-human other, is in itself a very human thing to do. Stoppard and Graham present nature as a mixture of extreme otherness and recognisable rhythms, as another aspect of the continuum of existence of which human beings are a part. Such a view can be seen as an up-to-date and scientific pan-romanticism. Furthermore, this valuing of abstraction entails not just a rational appreciation but a feeling of emotional engagement and (intellectual) pleasure. Here romanticism and the humanist perspective agree, since both criticise approaches to art and the world that are coldly logical or demand absolute axioms.

It is clear that mapping the exact relations between romantic philosophy of art and the contemporary humanist perspective is a topic for further research. But for the sake of epitomising the attitudes I have tried to delineate in this work, it could be said that from the humanist perspective chaos theory is, on the one hand, scientific rationalism shot with romanticism, and on the other hand, romantic individualism shot with philosophical realism.

The appropriation of chaos theory in literary studies, claim Matheson and Kirchoff (1997: 42-43), 'results primarily in repeated observations of the simultaneous presence of "order" and "disorder" in various literary works, making their authors' optimistic claims seem as mysterious as a declaration that a revolutionary critical school was to be founded exclusively on the search for opposing images of "light" and "darkness" in literature'. I do not, however, want to dismiss all of the chaos-and-literature approaches quite so readily. While chaos theory should not be taken

as the sole basis of anything as extensive as a new approach to literature and its study, examining its role in the recent discussion has been valuable as an illustration of the handling of a number of important theoretical issues. It is natural for human beings, including literary scholars, to ponder on the existence of patterns, where they come from, and what are the elements that do not fit a particular pattern. It is equally clear that in all representation there is an interaction between pattern and disorder, and chaos theory appeared as the perfect model for reinventing those issues in the context of literary analysis.

The reason why chaos theory has drawn so much attention from authors and literary critics is because it suits many of the themes discussed in late-twentieth-century literature and literary theory, both those based on poststructuralist theory and the humanist ones considered here (see chapter 1). However, I would also suggest that the reasons for the overly enthusiastic adoption of physics within literary analysis in the last few decades were also tied to a particular cultural context that may not exist anymore. The difference between the 1990s and today is that we now know that our discussion of order and disorder in literature is part of a larger vision of how patterns are perceived and how dynamic systems (including ourselves) interact. Thus there is no longer a need to forcefully argue for the existence of that larger vision by adopting natural scientific language into literary studies. Rather, literary scholars might now go on to develop a way of talking about patterns and their dynamic interaction in the vocabulary of literary studies, as well as looking for interdisciplinary connections with fields such as cognitive studies that are similarly involved with human pattern-recognition. As to other areas of further research, I have suggested a few avenues where the conceptualisations formed with the help of chaos theory could be developed. Many of them are already visible in the rhetorical approaches to narratology, the theories of embodied posthumanity and in the growing interest in the concept of mimesis.

As a conclusion to this study and to my efforts at understanding chaos, order and meaning, I would like to quote Mo, the

narrator of Jenny Diski's novel *Rainforest* (1987/1988: 17-18). After years of staring too closely at the seething biodiversity of the jungle, Mo wants to turn her back on all that is uncontrollable:

> I know chaos but the words I have for it won't do, nor the thoughts. I will not allow chaos into my mind any more, and if someone has made it into an abstract symbol then I applaud them for making it unnecessary to use words, or to tear one's mind to pieces in the effort to make sense of what is not sensible.

I sympathise with Mo's sentiment of wanting to make sure her brain will never again be forced to try to contain the paradoxes of nonlinear dynamics. However, as to words no longer being necessary for the understanding of chaos she is, fortunately, wrong. Although the abstract symbol has its function in science's efforts at constructing models, chaos must also be approached with words, and only through words and through the making of sense can it be developed as a humanist concept.

List of Abbreviations

By John Barth
OS   *On With the Story* (1996)
OUT   *Once Upon a Time: A Floating Opera* (1994)

By Jorie Graham
O   *Overlord* (2005)
RU   *Region of Unlikeness* (1997)

By Tom Stoppard
A   *Arcadia* (1993)

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