Imagining a Complex World

Science, Order and International Relations

Jonathon Louth

Thesis submitted for the degree of
Doctor of Philosophy
in the Discipline of Politics
School of History and Politics
University of Adelaide

November 2009

Abstract

How order is understood has been a central preoccupation of international relations theory. Within the Western imagination, order, banishing chaos, emerged from the Scientific Revolution and the Enlightenment as a knowable and calculable concept. Order became a known entity; it *is* the rational world. The irrational, that which didn't fit into neat delineations, was to be shunned. The resultant scientific method came to *represent* a reductionist, linear, and predictable outlook. Although it subsequently stepped down from its positivist heights, this Newtonian paradigm continues to inform (whether in opposition or in support) theory construction within social sciences, and, by extension, international relations theory. However, for over a century the sciences, divorced from the social sciences, have moved beyond this paradigm, with considerable attention being directed to the non-linear sciences. From this family of new sciences, complexity theory, drawing on and displacing chaos theory, has emerged over the last two decades as a genuine paradigmatic alternative.

This thesis argues that the incorporation of complexity theory at the meta-theoretical levels offers the opportunity to reconsider ontological and epistemological assumptions within the study of global politics. In detailing the presuppositions that best capture a complexity worldview, it is argued that complex adaptive systems, like the international system, exhibit emergent properties. Irreducibility, sensitivity to initial conditions, and self-organisation are shown to be central to comprehending how complex systems evolve, adapt and maintain high-energy far-from-equilibrium processes. Conversely, it is argued that dominant rationalist-based theories of international relations continue to seek out theories of natural equilibrium, which often reflect a transference of the Newtonian paradigm via a neoclassical economic ontology. Instead, it is argued that the international system should be viewed as a series of nested and overlapping complex adaptive systems that contains significant points of attraction, the most recognisable being the state. Moving towards an acceptance of the impact of the non-linear sciences at the meta-theoretical level will press the importance of intuition and interpretation to theories of international relations. Moreover, theories that absorb this commitment will more easily escape accusations of either irrelevancy for lacking a scientific base or of suffering from 'physics envy', in its traditional guise, because of its scientific base.

Declaration

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution to Jonathon Louth and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. I give consent to this copy of my thesis, when deposited in the University Library, being made available for loan and photocopying, subject to the provisions of the Copyright Act 1968.

I also give permission for the digital version of my thesis to be made available on the web, via the University's digital research repository, the Library catalogue, the Australasian Digital Theses Program (ADTP) and also through web search engines, unless permission has been granted by the University to restrict access for a period of time.

SIGNED:________________________________ DATE:_____________

Acknowledgments

Some things take longer than expected. The words that follow have slowly evolved into a discernable whole, over a time period in which I have completed a variety of tasks. During this time I have found employment as research associate through to lecturing large and challenging courses. I spent a good deal of the early years working shifts in a blue collar job and then found myself, in the later years, working for the government as a Ministerial advisor. I even found time to complete my teaching qualification. Through it all, the thesis has slowly simmered, the ideas forming the vast web of interconnections that follow. Yet, if it was not for the support of a considerable number of unique and incredibly supportive individuals the project would have perished quite some time ago.

Felix Patrikeeff deserves first mention. If it were not for his phone call, asking if I had considered applying for the PhD programme, then I would never had dared to venture along this treacherous yet ultimately rewarding path. For that I will forever be grateful. His encouragement, particularly early-on, and his final readings of the completed draft added sophistication and unity to the overall work. It is also to Ian Hall to whom much praise can be heaped. His involvement came late into the piece, but his insightful reading of each chapter has provided a depth that I would never had thought possible only a few short years ago. I would also thank Patrick Allington, whose sharp eye has made the thesis infinitely more readable.

To my colleagues at the University of Adelaide there are many to thank. I will be forever indebted to the administrative staff, the real heads of school, who have directed me past many of the pitfalls that await the unsuspecting. Among the academic staff there are many who are deserving of thanks, if only for their care and friendship. Of this group, it is to two individuals that I am most thankful. First is Clem Macintyre. Clem is someone I would consider a dear friend. He has helped me through some of my darkest days and he has given me encouragement and has not hesitated to assist me with all manner of appointments and opportunities. Not least, he has earned my respect as an excellent cricketer and a fine purveyor of a well-brewed beer. The other is Lisa Hill. Lisa, whom I also consider a friend, has, like Clem, been there through the difficult times. I have often referred to Lisa as my fairy godmother; she has looked out for me in so many different ways. Most obviously, this would include the research work and the joint publications we have undertaken. In essence, Lisa is a force for good.

Of course, the postgraduate community is always important for those undertaking higher education studies. It is a lonely world, and the sense of camaraderie that develops among those going through a similar experience is important, if only to stave-off those nagging doubts that look to undermine your every effort. There are many who I could name and each in their own way has contributed to the completion of this work. However, there are two that require special mention. Benito Cao, with his entertaining and engaging personality, has helped carry me through. It is to Dominic Stefanson that I dip my hat. For many years we shared coffee (and, occasionally, something a little stronger) and I like to think that our friendship reaches further than our many and varied discussions.

Away from academic circles, it is family and friends who bear the burden that a thesis delivers. So I will always be thankful to those who have, with me, endured. Whether it was my father's doting assistance, during that week in Victoria's high country, allowing me, after so long, to complete that elusive final draft. Or, to what assistance my mother could offer (indeed, not least the colourful upbringing that helped to shape my worldview), as it all contributed to finally finishing the task. By far and above, in terms of ongoing practical help and support for the duration of the enterprise, it is to my sister Peta-Anne, my sister-in-law Michelle and her husband Jeremy to whom I owe much. Of friends there are many, but I can state with certainty that if it were not for Mina and Martin (and, of course, Mietta) then the task of completing would have been all the harder.

Last, everything that follows is dedicated to Eli and Mary. Eli has grown up knowing of this strange entity, the thesis. I expect its completion will be akin to losing a sibling. Yet, just as the thesis has grown and matured so has he. It is with great pride that I see a young man emerging who has patiently allowed me the extra time to finish this task. From the experience I hope that he takes that something worth starting, is something worth finishing. To Mary, I can only say thank you. When I consider where we have come from, two young kids from the most humble of beginnings, to the opportunities we have provided ourselves, I shake my head in amazement. If it were not for you, the only one who was ever really aware of the difficulties faced, then none of this would have been possible. I feel that we have grown; learning from each other, but that it is I who has taken more from you, than what you may have taken from me. Thank you.

Here's to an unpredictable future.

Table of Contents

Table of Figures:

For Mary and Eli

Introduction

Complex Paradigms

Order, as a concept, is routinely neglected in the study of international relations. Discussions as to how the international system is *ordered*, or declarations of a new world *order*, to calls to overturn some nominal notion of an existing *order*, are commonplace. Consequently, the appearance of its centrality to the discipline becomes elevated. However, as Nicholas Rengger has shown, the 'problem of order' within International Relations (IR) theory is simply not sufficiently problematised.[1] What order *is* in itself is rarely discussed. It becomes *a priori* an oppositional point to chaos or anarchy; a neat set of arrangements that is thought to allow a rudimentary level prediction of the ebbs and flows, and the causes and effects, of power through and around social systems. Power can be tracked, delineated, compartmentalised and even balanced so that the global *order* might be properly understood. Because of this, IR theory has for too long been concerned with issues of continuity and typical patterned behaviour: that which can be

[1] Nicholas Rengger, *International Relations, Political Theory, and the Problem of Order: Beyond International Relations Theory?*, Routledge, London and New York, 1999, pp. xii-xiii, 3-12.

calculated or assumed because of isomorphisms drawn from linear conceptualisations of an outmoded scientific worldview. Alternatively, change, especially when rapid and largely unforeseen, is not readily accommodated into the accepted regularities of mainstream IR theory. Yet change, which should be understood as belonging to the process of order, is as important as the continuities. [2]

This thesis embraces the promise of unpredictability. Tackled is the dominant outlook of linearity and order that expresses surprise and incredulity towards events that do not match theoretical worldviews. Unfortunately, the most common response to such theoretical deficiencies is not a re-imagining of the perspectives in question. Instead the 'errors' are all too often shrouded through reference to anomalies or a failure to recognise or a miscalculated variable, or some such other *reason* as to why the imagined and the reality failed to meet. Unsettling a prevailing viewpoint is always an act of last resort. Yet if the best-laid plans or theories do unravel, what might, or, more accurately, what should occur is the realisation that the world is not always predictable. Many underlying assumptions that have become embedded in the 'modern' mind are challenged when, for example, it is discovered that one cause does necessarily result in an equal and opposite reaction; that the world is not a place of symmetry, of neat straight lines, of geometric triangles; or, that certainty and exactness are not as prevalent as what generations of nurturing have foretold.

To further refine the argument, as inheritors of Enlightenment thought the manner in which the world is conceptualised is constructed upon the foundations of rationalism, empiricism and reason. Reason, as defined from the dual wells of the Scientific Revolution and the Enlightenment, delivered humankind from superstition and the darkness that preceded it, has sought expression through abstraction in mathematics and the empiricism of science. The dominance of this

[2] See James Rosenau, *Turbulence in World Politics: a Theory of Change and Continuity*, Princeton University Press, Princeton, 1990.

manner of thinking is not surprising, given the revelatory explanations of 'how things worked' that accompanied, when thought of as distinct movements, these significant intellectual revolutions. Much of the change brought upon the world in recent centuries has occurred because of, or in line with, many of the revelations that occurred through this period. Science, technology, industry and the *idea* of progress stoked the engines of change and of modernity. The mysteriousness of the universe was being undressed and exposed. The world, like a vast machine, was being dissected, classified and, most importantly, understood by those beyond university cloisters. In this world, mankind (and it was very much driven by men) reaped and sowed innovation, cementing its knowledge and control over its own environment.

Despite the perceived ability to understand and to reveal the true nature of things, control, universality and order eluded those who have sought it over the most pressing human concerns, those that are important to the well-being of societies. Disease has not been purged and, indeed, new calamities emerge sporadically. Mental illness is increasing, if only in recognition, and what is evident is that the mind appears to be beyond simple comprehension. Poverty and the distribution of wealth remains a perennial issue, and this is felt most indiscriminately among those populations that have had the misfortune to have wrestled with famine. Significantly, the natural environment, that which mankind of the Enlightenment thought conquerable and able to be brought to heel for the interest of man, is arguably one of the most telling examples of how the folly of a particular worldview has encouraged, legitimised and even compelled particular paths of progress for societies to pursue. Environmental devastation is the likely cross that future generations will bear for the mode of development that the world's societies became interdependently locked into. Importantly, in context of this thesis, which looks at how we theorise and imagine international relations, conflict too has not disappeared. Notions like trust and cooperation cannot be adequately modeled so as to allow accurate prediction, nor can major ruptures or disturbances (an important element for any theory claiming a positivist lineage is its ability to prove it worthiness via accurately representing the world around). Understanding human societies and how they interact, emerge, rupture, how groups form and individuals effect change, challenges theories whose foundations are built upon scientific outlooks of this type. For many others, this position was nothing if not self-evident. Put in a simple way, mathematical equations and scientificisms do not capture the essence of what it is to be human and to what it is to interact with other humans, be it individually or as a group.

Such thoughts are easily enough put and criticism of the encroachment of science into the social realm is hardly new (the Romantics being an obvious example of the rejection of Enlightenment science). Similarly, one can point to counter-Enlightenment thinkers in general, or to the many thinkers who would fall under the banner of critical theory. However, what has been misplaced in much of the debate is an understanding of how the boundaries and parameters of the idea of science have framed a collective understanding. Science and how it may affect understanding the social, is borne of a singular view of what science *is*: Newtonian reductionism. It is this first impression that is hard to break. However, if the idea of what science *is* could be altered, then the possibility arises that science may offer something beyond notions of exactness and certainty. This is a difficult proposition, as the positivist understanding of the world, despite its comparative fall from grace, is still seen very much as the defining worldview when shifting ideas from the sciences to what are commonly referred to as the social sciences. Yet work in the hard and natural sciences has in many areas looked to non-linear approaches. Newtonianism has been challenged by the irregularities spawned by research into a considerable array of emerging disciplines. For this thesis, it is chaos and complexity theory that are the defining theoretical turns that offer a reinvigoration of how the science in social *science* can be re-imagined.

Complexity theory can be understood as a gathering of interconnected ideas that form the basis of an understanding of how non-linear dynamical systems function and remain viable. Complexity, in this sense, refers to the emergent phenomena that arise through the interaction of parts. It is here that traditional models and thinking have had difficulty accommodating events and circumstances that have not followed a linear progression. Importantly, the central argument is constructed not only on developing an appreciation of the many lessons offered by complexity theory, but it is also about recognising that the majority of previous attempts to incorporate the theory have been less than adequate.[3] Furthermore, and supporting the previous claim, the underlying assumptions and development have not been properly explored in the international relations literature, something this thesis seeks to do for the first time. Rengger, for example, refers to a 'dialectic of order',[4] an idea that gels with a complex[5] notion of feedback and continual emergence, and yet no serious complexity-based research within the international relations discipline has examined this notion at length. Most attempts at incorporating complexity theory within the literature look at patching it to existing frameworks as a novel methodological approach.[6] Yet this thesis argues that complexity theory is not about a new methodological approach, but a meta-theoretical commitment to an alternative paradigm, which may assist further theory-building. It is here that David Earnest and James Rosenau draw a correct conclusion when they write that the 'epistemology and ontology of complex systems are poorly defined'.[7] This thesis explores how these meta-theoretical foundations may be conceptualised and harnessed for theory-building in the discipline of international relations. The process begins by addressing the divide between the linear and the non-linear.

---

[3] For example see David C. Earnest and James N. Rosenau, 'Signifying Nothing? What Complex System Theory Can and Cannot Tell Us about Global Politics' in Neil E. Harrison, ed., *Complexity in World Politics: Concepts and Methods of a New Paradigm*, State University of New York Press, Albany, 2006, pp. 143-63.

[4] Rengger, *International Relations, Political Theory, and the Problem of Order*, pp. 18-19, 106-11.

[5] Complex, complexity and complexity theory will be used interchangeably unless otherwise indicated.

[6] For example see Robert Axelrod, T*he Complexity of Cooperation: Agent-Based Models of Conflict and Cooperation*, Princeton University Press, Princeton, 1997; Lars-Erik Cederman, *Emergent Actors in World Politics; How States and Nations Develop and Dissolve*, Princeton University Press, Princeton, 1997; Robert Geyer, 'Beyond the Third Way: The Science of Complexity and the Politics of Choice', *British Journal of Politics and International Relations,* vol. 5, no. 2, 2003, pp. 237-57; With the exception of the Earnest and Rosenau title above Neil E. Harrison, ed., *Complexity in World Politics: Concepts and Methods of a New Paradigm*, State University of New York Press, Albany, 2006.

[7] Earnest and Rosenau, 'Signifying Nothing?', p. 145.

A Non-Linear World

Linearity vis-à-vis non-linearity is very much a cornerstone of this thesis. The introduction of complexity theory offers new insights from the study of non-linear system dynamics, representing a move away from linear methods of analysis that have tended to be reductionist and focused on the idea that the components of a system can be examined separately. Linear methods bear a resemblance to car maintenance, whereby the mechanic can consider each and every part independently of the others, enabling her to dismantle the entire vehicle and then reassemble it and expect the car to be in perfect working order. This is not only typical, but a fundamental property of closed systems. Complex systems, which include political and social systems, are not closed systems and should not be examined as such. By way of a definitional starting point, John Holland captures the essence of linearity when he suggests that:

> it is little known outside the world of mathematics that most of our mathematical tools, from simple arithmetic through differential calculus to algebraic topology, rely on the assumption of linearity. Roughly linearity means that we can get a value for the whole by adding up the value of the parts. More carefully a *function* is *linear* if the value of the function, for any set of values assigned to its arguments, is simply a weighted sum of those values.[8]

It is this form of additive logic that has flowed unrestrained into the social sciences, all the time seeking rule-inspiring axioms. Cause and effect in the linear sense have predominated, built from natural laws,[9] allowing IR theory-building in the mainstream to make a breadth of claims based on predictability and orderly universal realms of relatively uncomplicated parts. This is the pursuit of a science of international relations, and it emerges both implicitly and explicitly in accounts

---

[8] John H. Holland, *Hidden Order: How Adaptation Builds Complexity*, Helix Books, Reading, 1995, p. 15.

[9] Wei-Bin Zhang states that 'Natural laws, once discovered, maintain structural stability in the sense that they can be repeated in a predictable way under certain circumstances. Natural laws are invisible and intangible but appear to exist everywhere and always. Newton's laws are valid in a predictable way; so is Einstein's relativity theory. Water boils in the same way in Japan, Sweden and Australia. Under given conditions it boils at predictable temperatures at standard atmospheric presses. Snow forms much in the same way under similar conditions all over the world. Observations of natural law are reproducible. The regularity of natural laws depend on the same conditions in the same experiments always giving the same results anywhere in the world at any time.' See Wei-Bin Zhang, 'Theory of Complex Systems and Economic Dynamics', *Nonlinear Dynamics, Psychology, and Life Sciences*, vol. 6, no. 2, 2002, p. 92.

of the international system. In this respect, the quest for a science of international relations is an 'elusive quest'.[10] In its most explicit form, the direct emulation of the natural sciences has largely been unsuccessful:

> [as] its capability of predicting the outcome of competition (war or peace?) has been very limited. Perhaps this is because too many variables seem to be required, intuitively, to describe the interactions between nations. Also, nations are composed of multitudes of individually complex people, making it hard to believe that the international variables, representing their collective behaviours, can satisfy relatively simple functional relationships. Any easily expressible theory, relating such variables, is bound to be incomplete and thus suspect, whether the theory is expressed verbally or mathematically.[11]

Indeed, John Lewis Gaddis, the noted historian and critic of positivist IR theory, argued that a 'quantitative fallacy' existed for those scholars who sought a scientific understanding of the regularities of war, as it is 'easier to count events related to war than to peace'.[12] Yet the implicit effects are more insidious, as it is the scientific imagination that shapes analogies and theory-making more generally. For example, when speaking of causation it is important to avoid the 'image of billiard balls colliding in a Newtonian universe'.[13] The difficulty here is that cause is contingent, and should not be surrendered to categorical universalisms.[14] Instead, the linear and predictable idea of causation should be let go of, and in its place presuppositions that shape causal relationship and define

---

[10] See Yale H. Ferguson and Richard W. Mansbach, *The Elusive Quest: Theory and International Politics*, University of South Carolina Press, Columbia, 1988.

[11] Alvin M. Saperstein, 'The Prediction of Unpredictability: Applications of the New Paradigm of Chaos in Dynamical Systems to the Old Problem of the Stability of a System of Hostile Nations' in L. Douglas Kiel and Euel Elliot, eds, Chaos Theory in the Social Sciences: Foundations and Applications, University of Michigan Press, Ann Arbor, 1996, p. 139.

[12] John Lewis Gaddis, 'International Relations Theory and the End of the Cold War', *International Security*, vol. 17, no. 3. 1992, p. 25.

[13] Milja Kurki, *Causation in International Relations: Reclaiming Causal Analysis*, Cambridge University Press, Cambridge, 2008, p. 132.

[14] John Lewis Gaddis, 'In Defence of Particular Generalizations: Rewriting Cold War History, Rethinking International Relations Theory' in Elman, Colin and Elman, Miriam Fendius, eds, *Bridges and Boundaries: Historians, Political Scientists and the Study of International Relations*, Massachusetts Institute of Technology Press, Cambridge, 2001, p. 312.

certain regularities of behaviour should emerge.[15] This is effectively blurring the line between cause (measured by the material) and constitutive (ideational);[16] the false dichotomy of that separates positivism and post-positivism.[17] Because of this, complexity theory should not be used as a straightforward methodological application, as the same age-old problems would very quickly emerge, not least of which is the 'black box' perception of the impermeable idea of the state (when presenting a simple interconnected network of states).[18] Theories supported by a non-linear meta-theoretical base should not be repeating the same mistakes. To show how this might be done, this thesis draws on the following literature.

Reviewing the Literature[19]

The thesis is largely theoretical and draws on literature from several distinct areas. Three broad realms can be identified. The first area concerns itself with the development of scientific thought and the emergence of a Newtonian-informed social science. It draws upon thinkers and general works that are associated with two important periods of Western civilization. The first is the Scientific Revolution, the period typically traced from the mid-point of the sixteenth century through to the end of the seventeenth century.[20] The Scientific Revolution encompassed great advances; notable achievements are found in the works of, among others, Johannes Kepler[21] and Galileo Galilei.[22] However, the most

---

[15] As an overview on the difficulties of accommodating causal analysis in IR theory, see Kurki, *Causation in International Relations*, pp. 132-44.

[16] ibid., p. 132.

[17] See Chapter Four.

[18] See Chapter Five.

[19] Because of the density of the footnotes in this section the first subsequent citation will appear in its full form to assist the reader. Beyond any second usage citations will revert to the typically accepted shortened format.

[20] Noteworthy secondary texts include: H. Floris Cohen, *The Scientific Revolution: A Historiographical Inquiry*, University of Chicago Press, Chicago, 1994; Emily Grosholz, *Cartesian Method and the Problem of Reduction*, Clarendon Press, Oxford, 1991.; Peter Harrison, 'Was there a Scientific Revolution?', *European Review*, vol. 15, no. 4, 2007, pp. 445-57; Alexandre Koyré, *Newtonian Studies*, The University of Chicago Press, Chicago, 1965; G. A. J. Rogers, 'Descartes and the Method of English Science', *Annals of Science*, vol. 29, no. 3, 1997, pp. 237-55; Michael White, *Isaac Newton: the Last Sorcerer, Fourth Estate*, London, 1997.

[21] See Ernan McMullin, 'The Impact of Newton's Principia on the Philosophy of Science', *Philosophy of Science*, vol. 68, no. 3, 2001, pp. 279-310.

[22] Rupert A. Hall, *From Galileo to Newton, 1630-1720: The Rise of Modern Science 2*, Fontana Collins, 1963; Emily Grosholz, 'Geometry, Time and Force in the Diagrams of Descartes, Galileo, Torricelli and

significant impact, in respect to how we think about science, came from the work of René Descartes, who published in the first half of the seventeenth century,[23] and Sir Isaac Newton, who lived at the end of the seventeenth and into the early eighteenth.[24] It is important to appreciate the interplay between Newtonian and Cartesian schools of thought through this period. Cartesian (and Lebnizian) ideas held considerable sway upon continental Europe long after the publication of Newton's *Philosophiæ Naturalis Principia Mathematica*.[25] Here, the distinction between the inductive and deductive approaches played out. Although the apparent empiricism of Newton's inductive methods won out, the Cartesian deductive methods of first principles still holds influence. However, as Voltaire acknowledged, Newton was to eventually dominate scientific thought,[26] absorbing Cartesian lessons. Newtonianism, the idea, emerged from this period and flowed into the next.

The second period in question is the Age of Enlightenment.[27] This was largely centred on the eighteenth century, with Voltaire's death in 1778 often taken as the Enlightenment's end point. However, it is the influence of the Scottish Enlightenment that figures prominently here is the work of Adam Smith, whose *An Inquiry Into the Nature and Causes of the Wealth of Nations*[28] oversaw the

---

Newton', *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association*, vol. 2: Symposia and Invited Papers, 1988, pp. 237-48.

[23] René Descartes, *Discourse on Method and Related Writings*, trans., Desmond M. Clarke, Penguin, London, 1998 [1637]; René Descartes, *Meditations on First Philosophy: with Selections From the Objections and Replies*, trans. and ed. John Cottingham, Cambridge University Press, New York, 1996 [1641].

[24] Isaac Newton, *Mathematical Principles of Natural Philosophy and His System of the World*, [1687], trans. Andrew Motte [1729], trans. Revised, and supplied with an historical and explanatory appendix by Florian Cajori, University of California Press, Berkeley, 1934.

[25] For a good overview of the interactions between Newtonians and so called anti-Newtonians in the eighteenth century, see Yahuda Elkana, 'Newtonianism in the Eighteenth Century', *The British Journal for the Philosophy of Science*, vol. 22, no. 3, 1971, pp. 297-306.

[26] Voltaire, 'Letter XIV on Des Cartes and Sir Isaac Newton' in *Letters Concerning the English Nation*, Peter Davies, London, 1926.

[27] A selection of texts sourced include: Isaiah Berlin, *The Age of Enlightenment: Selected, with Introduction and Commentary*, Mentor Books, New York, 1956; Carl L. Becker, *The Heavenly City of the Eighteenth Century Philosophers*, Yale University Press, New Haven, 1932; Ernst Cassier, *The Philosophy of the Enlightenment*, trans. Fritz C. A. Koelln and James P. Pettegrove, Princeton University Press, Princeton, 1968: James Farr, 'Political Science and the Enlightenment of Enthusiasm', *American Political Science Review*, vol. 82, no. 1, 1988, pp. 51-69; Lisa Hill, *The Passionate Society: The Social, Political and Moral Thought of Adam Ferguson*, Springer, Dordrecht, 2006.

[28] Adam Smith, *An Inquiry Into the Nature and Causes of the Wealth of Nations*, Campbell, R.H., and Skinner, A.S., eds, Clarendon Press, Oxford, 1979 [1776].

beginning of an economic ontology for understanding human affairs. The other important Scottish Enlightenment thinker is David Hume. As a contributor he stands apart almost as much as he is also seen to belong to the period. A number of his works are consulted throughout this thesis.[29] Indeed, his sceptical empiricism and his thoughts on causation have helped to and continue to reinvigorate philosophical enquiry.[30] One such significant contribution can be found in his essay 'On the Balance of Power', which noted the fallacy of the existence of any such balance.[31]

However, as is often the case, narratives of historical periods cannot be contained to singular vision. Thomas Hobbes, although aware of many of the scientific advances, is not usually considered an Enlightenment thinker, not least of all because he was born just before this time. Yet, his *Leviathan* is a seminal text when examining key political texts of the period.[32] Counter-Enlightenment thought is also central, most notably the work of Giambattista Vico; in particular, his book *The New Science*, with its incredulousness directed toward Cartesian thought.[33] In more recent times, the work of Isaiah Berlin has sharpened the focus on this period.[34] However, despite the criticism of counter-Enlightenment thinkers and

[29] The works of David Hume that have been consulted include: 'That Politics May be Reduced to a Science' in *Selected Essays*, Oxford University Press, Oxford, 1996 [1741]; *A Treatise of Human Nature: Book II: Of the Passions*, edited, with analytical index, by L.A. Selby-Biggs, Clarendon Press, London, 1888 [1739]; *The Natural History of Religion*, edited with introduction by H.E. Root, Adam & Charles Black, London, 1956 [1777].

[30] Of course, it is Kant most look to for an example here, however, in respect to international relations see the work of Alexander Wendt or Patomäki and Wight. At a meta-theoretical level his impact can be seen (via Kant) in Roy Bhaskar's work on critical realism. See Bhaskar, Roy, 'Philosophy and Scientific Realism' in Archer, Margaret; Bhaskar, Roy; Collier, Andrew; Lawson, Tony and Norrie, Alan, eds, *Critical Realism: Essential Readings*, Routledge, London, 1998.

[31] David Hume, 'On the Balance of Power', *Essays, Moral, Political, and Literary*, Eugene F. Miller, ed., Liberty Classic, Indianapolis, 1985 [1777];

[32] Thomas Hobbes, *Leviathan*, C. B. Macpherson, ed., Penguin Books, Harmondsworth, 1968 [1651]. On his continued influence in international relations see Michael C. Williams, 'Hobbes and International Relations: A Reconsideration', *International Organization*, vol. 50, no. 2, 1996, pp. 213-36.

[33] Giambattista Vico, *The New Science*, 3rd ed., eds and trans Thomas Goddard Bergen and Max Harold Fisch, Cornell University Press, Ithaca, 1968 [1744] and Giambattista Vico, *Vico: Selected Writings*, Leon Pompa, ed. (and trans.), Cambridge University Press, Cambridge, 1982. Other works consulted include: Benedetto Croce, *The Philosophy of Giambattista Vico*, Trans. R. G. Collingwood, Russell and Russell, New York, 1964; William J. Mills, 'Positivism Reversed: The Relevance of Giambattista Vico', *Transactions of the Institute of British Geographers, New Series*, vol. 7, no. 1, 1982, pp. 1-14; Leon Pompa, *Vico: A Study of the 'New Science'*, Cambridge University Press, Cambridge, 1990.

[34] Isaiah Berlin work's consulted included: 'Divorce between the sciences and the humanities', in Henry Hardy and Roger Hausheer, eds, *The Proper Study of Mankind: An Anthology of Essays*, Farrar, Straus and

from other quarters, like the Romantics,[35] positivism emerged as a strong force within the nineteenth century, with scientific, social and political thought intermingling and merging in a manner not seen before.[36] Two works are important here. Pierre-Simon de Laplace's *A Philosophical Essay on Probabilities,*[37] which, as a thought experiment, argued the case for the possibility of a calculable world. The other is Auguste Comte's *A General View of Positivism*, coining not only the term positivism, but also sociology.[38] The world, through this period, was believed to be increasingly solvable.

Of course, the story does not end here, as a significant paradigm shift[39] in the sciences was beginning to stir. The second distinct area the literature within the thesis focuses on is the development and growing importance of the non-linear sciences.[40] A good deal of this literature is concerned with the development of chaos theory. This is a field that has attracted a vast number of adherents,[41] with Ilya Prigogine and Isabelle Stengers's *Order Out of Chaos: Man's New Dialogue with*

Giroux, New York, 1997; 'The Origins of Cultural History: 'Geisteswissenschaft' and the Natural Sciences Vico versus Descartes', Second of three Gauss lectures given at Princeton in 1973. Available online Isaiah Berlin Virtual Library, http://berlin.wolf.ox.ac.uk/lists/nachlass/origins2.pdf (accessed 25/3/2006); *Against the Current: Essays on the History of Ideas*, The Hogarth Press, London, 1980.

35 Blake, William, *Annotations to Sir Joshua Reynolds' Discourses*, (c. 1808)' in Lorenz Eitner, *Neoclassicism and Romanticism 1750-1850*, vol. 1 (sources and documents in the history of art series), Prentice-Hall International, London, 1971.

36 For example: Robert C. Bannister, '"The Survival of the Fittest is Our Doctrine": History or Histrionics?', in John Offer, ed., *Herbert Spencer: Critical Assessments of Leading Sociologists*, vol. 2, Routledge, London, 1999.

37 P.S. Laplace, *A Philosophical Essay on Probabilities*, 6th ed., Trans. by F. W. Truscott and F. L. Emory, Dover Publications, New York, 1951 [1825].

38 Auguste Comte, *A General View of Positivism*, J.H. Bridges trans., Robert Speller & Sons, London, 1957 [1848].

39 With direct reference to the ideas of Thomas Kuhn. In particular, his *The Structure of Scientific Revolutions*, (International Encyclopaedia of Unified Science, vol. 2, no. 2) University of Chicago Press, Chicago, 1962, and; 'The Function of Measurement in Modern Science', *Isis*, vol. 52, no. 2, 1961, pp. 161-93.

40 A particularly important article here, with a detailed and thoughtful historical analysis, is David Aubin and Amy Dahan Dalmedico's 'Writing the History of Dynamical Systems and Chaos: Longue Dureé and Revolution, Disciplines and Cultures', *Historia Mathmatica*, vol. 29, 2002, pp. 273-339.

41 Michael Barnsley, *Fractals Everywhere*, Academic Press, San Diego, 1988; Karl-Heinz Becker and Michael Dörfler, *Dynamical Systems and Fractals: Computer Graphics Experiments in Pascal,* trans. Ian Stewart, Cambridge University Press, Cambridge, 1989; John Briggs, *Fractals: The Patterns of Chaos: Discovering a New Aesthetic of Art Science and Natur*e, Simon & Schuster, New York, 1992; Kenneth Falconer, *Fractal Geometry: Mathematical Foundations and Applications*, 2nd ed., Wiley, Chichester, 2003; N. Katherine Hayles, *Chaos Bound: Orderly Disorder in Contemporary Literature and Science,* Cornell University Press, Ithaca and London, 1990; Edward N. Lorenz, 'Deterministic Nonperiodic Flow' *Journal of the Atmospheric Sciences*, vol. 20, no. 1, 1963, pp. 130-41; Heinz-Otto Peitgen, Hartmut Jürgens and Dietmar Saupe, *Chaos and Fractals: New Frontiers of Science*, Springer-Verlag, New York, 1992.

Nature remaining of key significance within the field.[42] The other significant contributor, for his visual representation of chaos, is Benoit Mandelbrot.[43] His fractal images have also attracted followers, who claim similar scaling effects in their own fields.[44] A large part of this movement can be tracked via the burgeoning literature in the popular science area. Popular science publications are indicative of how the scientific imagination transcends boundaries, and influences how the social world is imagined; many are canvassed through the thesis.[45] The two most important works here are James Gleick's bestselling *Chaos: Making a New Science*, which quickly popularised ideas like the butterfly effect.[46] The other popular publication, although not as commercially successful as Gleick's, was M. Mitchell Waldrop's *Complexity: The Emerging Science at the Edge of Order and Chaos*.[47] Waldrop tells the story of complexity theory and, in particular, the birth of the Santa Fe Institute, an important multi-disciplinary, complexity theory research centre. Indeed, any examination of non-linear science quickly leads to the field of complexity theory, where a proliferation of literature has occurred over the past decade and a half.[48] The literature here is extensive, but two Santa Fe alumni stand

---

[42] Ilya Prigogine and Isabelle Stengers, *Order Out of Chaos: Man's New Dialogue with Nature*, New Science Library, Boulder, 1984. See also, Ilya Prigigone, *The End of Certainty: Time, Chaos, and the New Laws of Nature*, The Free Press, New York, 1997.

[43] The works of Benoit Mandelbrot that have been cited are: 'Fractal Geometry: What is it, and What does it do?', *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences*, vol. 423, no. 1864, 1989, pp. 21-87; 'Fractals and an Art for the Sake of Science', *Leonardo: Computer Art in Context Supplemental Issue*, no. 2, 1989, pp. 21-4; 'Fractals and the Rebirth of Iteration Theory', in Peitgen, Heinz-Otto and Richter, Peter H., *The Beauty of Fractals: Images of Complex Dynamical Systems*, Springer-Verlag, Berlin, 1986; 'People and Events behind the "Science of Fractal Images"' in Heinz-Otto Peitgen and Dietmar Saupe, *The Science of Fractal Images*, Springer-Verlag, New York, 1988; 'Selected Topics in Mathematics, Physics and Finance Originating in Fractal Geometry', in M. Novak, Miroslav, ed., *Thinking in Patterns: Fractals and Related Phenomena in Nature*, World Scientific, New Jersey, 2004; *The Fractal Geometry of Nature*, rev. ed., W.H. Freeman and Company, New York, 1983 [1977].

[44] A good example here is Edgar E. Peters, *Fractal Market Analysis: Applying Chaos Theory to Investment and Economics*, John Wiley & Sons, New York, 1994.

[45] Philip Ball, *Critical Mass: How One Thing Leads to Another*, Arrow Books, London 2004; John D. Barrow, *Impossibility: The Limits of Science and the Science of Limits*, Vintage, London, 1999; Peter Dear, *Revolutionizing the Sciences: European Knowledge and its Ambitions, 1500-1700*, Palgrave, Houndsmill, 2001; John Gribbin, *Deep Simplicity: Chaos, Complexity and the Emergence of Life*, Penguin Books, London, 2004; Steven Johnson, *Emergence: The Connected Lives of Ants, Brains, Cities and Software*, Allen Lane: The Penguin Press, London, 2001; Ziauddin Sardar and Iwona Abrams, *Introducing Chaos*, Icon Books, Cambridge, 1999 [1998]; Ian Stewart, 'Portrait of Chaos' in Nina Hall, ed., *The New Scientist Guide to Chaos*, Penguin Books, London, 1991.

[46] James Gleick, *Chaos: Making a New Science*, Sphere Books, London, 1988.

[47] M. Mitchell Waldrop, *Complexity: The Emerging Science at the Edge of Order and Chaos*, Simon and Schuster, New York, 1992.

[48] A selection of core titles would include: John Brockman, ed., *The Third Culture: Beyond the Scientific Revolution*, Simon & Schuster, 1995, http://www.edge.org/documents/ThirdCulture/d-Contents.html,

out as compulsory reading for anyone wishing to delve into the complexity sciences. John Holland's *Hidden Order: How Adaptation Builds Complexity*,[49] outlines the core ideas behind the complex adaptive system. The other is Stuart A. Kauffman, whose two books *At Home in the Universe: The Search for Laws of Self-Organization and Complexity* and *The Origins of Order: Self-Organization and Selection in Evolution*[50] underpin the central concept of self-organisation. Together they form a foundational starting point for anybody who wishes to study complex systems.

The third broad area is concerned with IR theory. Again, the literature is vast and, in general terms, a diverse and broad range has been drawn upon.[51] Because the argument centres on the meta-theoretical implications of complexity theory upon IR theory, core texts across a range of theoretical traditions have been consulted. The English School, especially Hedley Bull's *The Anarchical Society: A Study of*

(accessed 14/02/2006); David Byrne, 'Complexity, Configuration and Cases', *Theory, Culture & Society*, vol. 22, no. 5, pp. 95-110; David Byrne, *Complexity Theory and the Social Sciences: An Introduction*, Routledge, London, 1998; Paul Cilliers, 'What Can We Learn From a Theory of Complexity', *Emergence*, vol. 2, no. 1, 2000, pp. 22-33; Paul Cilliers, *Complexity and Postmodernism,* Routledge, London & New York, 1998; Jack Cohen and Ian Stewart, *The Collapse of Chaos: Discovering Simplicity in a Complex World*, Penguin, London, 1995; Chris Goldspink, 'Contrasting Linear and Nonlinear Perspectives in Contemporary Social Research', *Emergence*, vol. 2, no. 2, 2000, pp. 72–101; Christopher G. Langton, 'Self-reproduction in cellular automata', *Physica D: Nonlinear Phenomena*, vol. 10, no. 1-2, 1984, pp. 135-44; Simon A. Levin, 'Complex Adaptive Systems: Exploring the Known, the Unknown and the Unknowable', *Bulletin of the American Mathematical Society*, vol. 40, no. 1, 2003, pp. 3-19; Steven E. Phelan, 'What is Complexity Science, Really?', *Emergence,* vol. 3, no. 1, 2001, pp. 120-36; John Urry, *Global Complexity*, Polity Press, Cambridge, 2003; Stephen, Wolfram, *A New Kind of Science*, Wolfram Media, Champaign, 2002. See also John Urry, 'The Complexity Turn', *Theory, Culture and Society*, vol. 22, no. 5, 2005, p. 2.

49 John Holland, *Hidden Order: How Adaptation Builds Complexity*, Addison-Wesley, New York, 1995. More recent, and with a heavy focus on game theory and cellular automata, see John Holland, *Emergence: From Chaos to Order*, Oxford University Press, Oxford and New York, 1998.

50 Stuart A. Kauffman, *At Home in the Universe: The Search for Laws of Self-Organization and Complexity*, Oxford University Press, Oxford and New York, 1995; Stuart A. Kauffman, *The Origins of Order: Self-Organization and Selection in Evolution*, Oxford University Press, New York, 1993. And, more recently, see Stuart Kauffman, *Investigations*, Oxford University Press, New York, 2000.

51 In a far from exhaustive list, the following is indicative of the breadth of IR theory texts consulted: Barry Buzan and Ole Wæver, *Regions and Powers: The Structure of International Security*, Cambridge University Press, Cambridge, 2003; Molly Cochran, *Normative Theory in International Relations*, Cambridge University Press, Cambridge, 1999; John Lewis Gaddis, 'International Relations Theory and the End of the Cold War ', *International Security*, vol. 17, no. 3. 1992, pp. 5-58; J. P., Nettl, 'The State as a Conceptual Variable', *World Politics*, vol. 20, no. 4, 1968, pp. 559-92; Heikki Patomäki and Colin Wight, 'After Postpositivism? The Promises of Critical Realism', *International Studies Quarterly*, vol. 44, pp. 213-37; Michael Nicholson, *Causes and Consequences in International Relations*, Pinter, London, 1996; Nicholas Rengger, *International Relations, Political Theory, and the Problem of Order: Beyond International Relations Theory?*, Routledge, London and New York, 1999; pp. 62-70; J. David Singer, 'The Level-of-Analysis Problem in International Relations', *World Politics*, vol. 14, no. 1, 1961, pp. 77-92.

Order in World Politics,[52] and liberal approaches[53] are examined, primarily because of the normative claims of the former and rationalist base of the neo variant of the latter. However, realist thought receives considerably more attention.[54] The classical or traditional realism of Hans J. Morgenthau is a focal point. His enormously influential *Politics Among Nations: The Struggle for Power and Peace*,[55] with its often-misunderstood chapter on the 'Science of International Relations', is examined as an implicit acknowledgement of a Newtonian world. The other is the neorealist Kenneth N. Waltz.[56] His equally influential *Theory of International Politics*[57] recast the discipline of international relations. His work can be

52 A difficult group to categorise, but the following works are indicative of English School authors that have significantly added to the thesis: Hedley Bull, *The Anarchical Society: A Study of Order in World Politics*, 2nd ed., MacMillan, London, 1995; Hebert Butterfield, *International Conflict in the Twentieth Century: A Christian View*, Routledge and Kegan Paul, London, 1960; Ian Clark, *Reform and Resistance in the International Order,* Cambridge University Press, Cambridge, 1980; Martin Wight, *Four Seminal Thinkers in International Theory: Machiavelli, Grotius, Kant, Mazzini*, Gabrielle Wight and Brian Porter, eds, Oxford University Press, Oxford, 2005.

53 G. John Ikenberry, 'Institutions, Strategic Restraint, and the Persistence of American Postwar Order', *International Security*, vol. 23, no. 3, Winter 1998, pp. 43-78; Robert O. Keohane and Joseph S. Nye Jr., *Power and Interdependence*, 3rd ed., Longman, New York, 2001; Joseph Nye, 'Limits of American Power', *Political Science Quarterly*, vol. 117, no. 4, 2002-2003, pp. 545-59.

54 Realism in a remarkably diverse field. For example, some of the consulted works (minus Morgenthau and Waltz) are as follows: E. H. Carr, *The Twenty Years' Crisis 1919-1939: An Introduction to the Study of International Relations*, reissued with a new introduction and additional material by Michael Cox, Palgrave, New York, 2001; Morton A. Kaplan, 'The New Great Debate: Traditionalism vs. Science in International Relations', *World Politics*, vol. 19, no. 1,1966, pp. 1-20;Stephen D. Krasner, 'Rethinking the Sovereign State Model', *Review of International Studies*, vol. 27, no. 1, 2001, pp. 17-42; Robert O. Keohane, ed., *Neorealism and its Critics*, Columbia University Press, New York, 1986; Jeffrey Legro and Andrew Moavcsik, 'Is Anybody Still a Realist?', *International Security*, vol. 24, no. 2, pp. 5-55; John J. Mearsheimer, *The Tragedy of Great Power Politics*, W. W. Norton & Company, New York and London, 2003; Seán Molloy, 'Realism: A Problematic Paradigm', *Security Dialogue*, vol. 34, no. 1, 2003, pp. 71-85; Bradley A. Thayer, *Darwin and International Relations: On the Evolutionary Origins of War and Ethnic Conflict*, Kentucky University Press, Kentucky, 2004; Stephen M. Walt, 'International Relations: One World, Many Theories', *Foreign Policy*, no. 110, 1998, pp. 29-46; Arnold Wolfers, 'Actors in International Politics' in William T. R. Fox, ed., *Theoretical Aspects of International Relations*, University of Notre Dame Press, Notre Dame, 1959.

55 The key text here is Hans J. Morgenthau's, *Politics Among Nations: The Struggle for Power and Peace*, 4th ed., Alfred A. Knopf, New York, 1967 [1948]; Some of the secondary texts consulted include Murielle Cozette, 'Reclaiming the Critical Dimensions of Realism: Hans J. Morgenthau on the Ethics on Scholarship', *Review of International Studies*, vol. 34, no. 1, 2008, pp. 5-27; Anthony F. Lang Jr., 'Introduction' in *Hans Morgenthau, Political Theory and International Affairs: Hans J Morgenthau on Aristotle's the Politics*, ed. Anthony F. Lang Jr., Praeger, Westport, 2004; John J. Mearsheimer, 'Hans Morgenthau and the Iraq War: Realism Versus Neo-Conservatism', *Open Democracy: Free Thinking for the World*, 18 May 2005, http://www.opendemocracy.net/node/2522/pdf, date accessed 26/12/2007; Seán, Molloy, 'Truth, Power, Theory: Hans Morgenthau's Formulation of Realism', *Diplomacy and Statecraft*, vol 15, no. 1, 2004, pp. 1-34.

56 Waltz's works cited include: 'Evaluating Theories', American Political Science Review, vol. 91, no. 4, 1997, pp. 913-917; 'Structural Realism after the Cold War', *International Security*, vol. 25, no. 1, 2000, pp. 5-41; *Man, the State and War: A Theoretical Analysis*, Columbia University Press, New York, 1959. Important secondary text include Fred Halliday and, Justin Rosenberg, 'Interview with Ken Waltz', *Review of International Studies*, vol. 24, no. 3, 1998, pp. 371-86; Ewan Harrison, 'Waltz, Kant and Systemic Approaches to International Relations', *Review of International Studies*, vol. 28, no. 1, 2002, pp. 143-62.

57 Kenneth N. Waltz, *Theory of International Politics*, Addison-Wesley, Reading, 1987.

understood as an explicit representation, through its scientificisms, of a Newtonian world. Of course, these texts are closely aligned to the mythologising of the great IR debates. These mainstream approaches are quite 'happy with the dominant story' and its 'epic history', yet they are traditions that the field needs to step away from.[58] A meta-theoretical reappraisal should assist with this process.

Critical elements, representative of interpretive theories, also play a role,[59] with the emphasis being upon constructivist approaches.[60] The issue is, of course, how complexity theory can influence IR theory. The impact of complexity theory directly upon IR is noted.[61] Robert Jervis, with his realist *System Effects: Complexity in Political and Social Life*,[62] is one the best examples of this transition. But, for the

---

[58] Brian C. Schmidt, 'On the History and Historiography of International Relations' in Walter Carlsnaes, Thomas Risse and Beth A. Simmons, eds, *The Handbook of International Relations*, Sage, Thousand Oaks, 2002, pp. 3, 7-8.

[59] Critical perspectives will always represent breadth. Here, critical should be understood, as argued by Robert Cox, as theory that is interpretive, as opposed to being simply explanatory. Consider the following titles: Robert W. Cox, *Approaches to World Order*, with Timothy J. Sinclair, Cambridge University Press, Cambridge, 1996; James Der Derian, 'Post-Theory: The Eternal Return of Ethics in International Relations', in Doyle, Michael W. and Ikenberry, John G., *New Thinking in International Relations Theory*, Westview Press, Boulder, 1997; Stefano Guzzini, 'Structural Power: The Limits of Neorealist Power Analysis', *International Organisation*, vol. 47, no. 3, 1993, pp. 443-78; Frederick Kratochwil, 'Re-Thinking the "Inter" in International Politics', *Millennium: Journal of International Studies*, vol. 35, no. 3, 2007, pp. 495-511; John Vasquez, *The Power of Power Politics: From Classical Realism to Neotraditionalism*, Cambridge University Press, Cambridge, 1998.

[60] Ignoring Alexander Wendt, this includes: Jeffery T. Checkel, 'The Constructivist Turn in International Relations Theory', *World Politics*, vol. 50, no. 2, 1998, Stefano Guzzini,, 'A Reconstruction of Constructivism in International Relations', *European Journal of International Relations*, vol. 6, no. 2, 2000, pp. 147-182; Nicholas Onuf, *World of Our Making: Rules and Rule in Social Theory and International Relations*, University of South Carolina Press, Columbia, 1989; John Gerald Ruggie, 'The False Promise of Realism', *International Security*, vol. 20, no. 1, 1995.

[61] IR and complexity related titles include: Robert Axelrod, *The Complexity of Cooperation: Agent-Based Models of Conflict and Cooperation*, Princeton University Press, Princeton, 1997; Gregory G. Brunk, 'Self-Organized Criticality: A New Theory of Political Behaviour and Some of Its Implications', *British Journal of Political Science*, vol. 31, no. 2, 2001, pp. 427-45; Lars-Erik Cederman, 'Modeling the Size of Wars: From Billiard Balls to Sandpiles', *American Political Science Review*, vol. 97, no. 1, 2003, pp. 135-50; Lars-Erik Cederman, *Emergent Actors in World Politics; How States and Nations Develop and Dissolve*, Princeton University Press, Princeton, 1997; Walter C. Clemens Jr., *The Baltic Transformed: Complexity Theory and European Security*, Rowman and Littlefield Publishers, Boston, 2001; Neil E. Harrison, ed., *Complexity in World Politics: Concepts and Methods of a New Paradigm*, State University of New York Press, Albany, 2006; Hoffmann, Matt and Johnson, David, 'Change and Process in a Complex World: Using Complexity Theory to Understand World Politics, Paper presented at the Annual Meetings of the International Studies Association, Minneapolis, Minnesota, March 18-21, 1998; Emilian Kavalski, 'The Complexity of Global Security Governance: An Analytical Overview', *Global Society*, vol. 22, no. 4, 2008, pp. 423-43; Emilian Kavalski, 'The Fifth Debate and the Emergence of Complex International Relations Theory: Notes on the Application of Complexity Theory to the Study of International Life', *Cambridge Review of International Affairs*, vol. 20, no. 3, 2007, pp. 435-54.

[62] Robert Jervis, *System Effects: Complexity in Political and Social Life*, Princeton University Press, Princeton, 1997.

most part, it is argued that complexity theory is not adequately incorporated at a meta-theoretical level, or it is largely a case of it being used as a methodological overlay. Two important thinkers who do emerge through the thesis, and whose ideas have touched upon complexity theory, either directly drawing on the lessons of complexity theory or offering important avenues for the incorporation of complexity inspired ideas, are James N. Rosenau[63] and Alexander Wendt respectively.[64] Rosenau's *Turbulence in World Politics: a Theory of Change and Continuity*[65] is the title that opened the possibility of complexity to many IR theorists. Although his early work was steeped in behaviouralist thinking, this, and his subsequent work, has encouraged significant numbers of scholars to step into unfamiliar terrain. Differently, Wendt has had a larger impact upon the field. His article, 'Anarchy is What States Make of it: the Social Construction of Power Politics', has provided an IR theory catchphrase, and the book that followed, *Social Theory of International Politics*, placed him within the great debates of IR. Yet, the importance lies in that his 'thin' constructivism is open to the influence of

[63] The consulted works of James Rosenau include: 'Many Damn Things Simultaneously' in David S. Albert, and Thomas J Czerwinski, eds, *Complexity, Global Politics and World Affairs*, University Press of the Pacific, Honolulu, 1997; 'The Future of Politics', *Futures*, vol. 31, no. 9-10, 1999, pp. 1005-16; *Distant Proximities: Dynamics Beyond Globalization*, Princeton University Press, Princeton, 2003; *The Study of World Politics: Theoretical and Methodological Challenges*, vol. 1, Routledge, New York, 2006; David C. Earnest, and James N. Rosenau, 'Signifying Nothing? What Complex System Theory Can and Cannot Tell Us about Global Politics' in Harrison, Neil E., ed., *Complexity in World Politics: Concepts and Methods of a New Paradigm*, State University of New York Press, Albany, 2006; Peter H. Koehn and James N. Rosenau, 'Transnational Competence in an Emergent Epoch', *International Studies Perspectives*, vol. 3, no. 2, 2002, pp. 105-27. See also Yale H. Ferguson, and Richard W. Mansbach, *Remapping Global Politics: History's Revenge and Future Shock*, Cambridge University Press, Cambridge, 2004.

[64] The (prolific) work of Alexander Wendt that has been consulted includes: 'Collective Identity Formation and the International State', *American Political Science Review*, vol. 88, no. 2, 1994, pp. 384-396; 'Constructing International Politics', *International Security*, vol. 20, no. 1, 1995, pp. 71-85; 'How Not to Argue Against State Personhood: a Reply to Lomas', *Review of International Studies*, vol. 31, no 2, 2005, pp. 357-360; 'On Constitution and Causation in International Relations', *Review of International Studies*, vol. 25, no. 5, 2001, pp. 101-118; 'The Agent-Structure Problem in International Relations Theory', *International Organization*, vol. 41, no. 3, 1987, pp. 335-370; 'The State as Person in International Theory', *Review of International Studies*, vol. 30, no. 2, 2004, pp. 289-316; Ronald L. Jepperson, Alexander Wendt and Peter J. Katzenstein, 'Norms, Identity, and Culture in National Security', in Peter J. Katzenstein, ed., *The Culture of National Security: Norms and Identity in World Politics*, Columbia University Press, New York, 1996; Alexander Wendt and Raymond Duvall, 'Institutions and International Order' in Ernst-Otto Czempiel and James Rosenau, eds, *Global Changes and Theoretical Challenges: Approaches to World Politics for the 1990s*, Lexington Books, Lexington, 1989. In respect to secondary text, see Peter Lomas, 'Anthropomorphism, Personification and Ethics: a Reply to Alexander Wendt', *Review of International Studies*, vol. 31, no 2. , 2005, pp. 349-55; Steve Smith, 'Wendt's World', Review of International Studies, vol. 26, no. 1, 2000, pp. 151-63 and Colin Wight, 'State Agency: Social Action Without Human Activity', *Review of International Studies*, vol. 30, no. 3, 2004, pp. 269-280.

[65] James Rosenau *Turbulence in World Politics: a Theory of Change and Continuity*, Princeton University Press, Princeton, 1990.

complexity. In his article 'Why a World State is Inevitable', Wendt, clumsily, illustrates this possibility.[66] A great deal more literature than is listed here is dealt with, but this overview gives an impression of the diversity of thought when constructing an argument of the importance and centrality of science to how the social realm, and, for this thesis, how international relations are understood.

Critical Points

Two approaches to knowledge, which are connected by their opposition to each other, need to be addressed. The first is that of critical theory[67] or, to be precise, post-modernism and post-structuralism. This critical turn has offered, and continues to offer, significant insights into social worlds. Certainly, reflectivists challenge many of 'the ontological, methodological, epistemological and normative assumptions' of mainstream theories of IR.[68] It is difficult to argue that a level of reflection on how subjectivity is produced, and the consequent manner in which power can be thought to be constituted, does not offer important insights to how international politics might be understood. The difficulty occurs when the more extreme elements render scholarly insights that presuppose an external reality and empirical research obsolete,[69] undermining any attempt at a general theory on international relations. In doing so what is rejected is:

> the basic idea of an external reality … and if theory is reduced to social and linguistic constructions, then there is no need to prefer

[66] Alexander Wendt, 'Anarchy is What States Make of it: the Social Construction of Power Politics', *International Organization*, vol. 42, no. 2, 1992, pp. 384-96; Alexander Wendt, *Social Theory of International Politics*, Cambridge University Press, Cambridge, 1999; Alexander Wendt, 'Why a World State is Inevitable', *European Journal of International Relations*, vol. 9, no. 4, 2003, pp. 491-542.

[67] Critical theory draws from such diverse commentary as poststructuralism, neo-Gramscian, reformulated Marxism, a broad range of feminist thought and much that has emerged from the Frankfurt school. Martin Weber, 'Engaging Globalization: Critical Theory and Global Political Change', *Alternatives* vol. 27, 2002, p. 301.

[68] Anton du Plessis, 'International Relations Theory and the Discourse on Terrorism: Preliminary Reflections on Context and Limits', *Strategic Review for Southern Africa*, vol. 23, no. 2, 2001, p. 140.

[69] Of course, this claim is often vastly exaggerated. See James Der Derian, 'Post-Theory: The Eternal Return of Ethics in International Relations', in Michael W. Doyle and John G. Ikenberry, *New Thinking in International Relations Theory*, Westview Press, Boulder, 1997, pp. 55-75, esp. 56-9.

> any scholarly (including post-structuralist) arguments to those made by an accidental pedestrian.[70]

The above quote has the severity of an oversimplification, yet the sentiment is important. Complexity theory moves away from hardened positivist claims that reduce the world to axioms from which all else can be built, but it does not step away from the idea of an observable and knowable world. What is observed and what is known may well be contingent, emergent, and more than the sum of the parts, but it is nonetheless real.

In addition, it is important to stress that revelatory claims made by many post-structuralists (and more often so by their subsequent followers) are often either overstated, or claim an unwarranted level of ownership of particular ideas. For example, when Michel Foucault argues that a 'corpus of knowledge, techniques, and "scientific" discourses is formed and becomes entangled with the practice of the power to punish',[71] his point is insightful and expressed in a manner distinct from other schools of thought. Indeed, the relationship between science, knowledge and power is a central tenet of this thesis, but it is not an argument that *belongs* or is peculiar to adherents of this type of critical theory. With a degree of animosity, Murielle Cozette notes that the adjective 'critical' has been hijacked by the self-appointed critical theorists. In respect to IR theory this has meant, for Cozette, that schools of thought like realism are 'implicitly presented as antithetical' and as being uncritical (which is where the 'insidious high-jacking [sic]' occurs).[72]

---

[70] Torbjørn L. Knutsen, A *History of International Relations Theory*, 2nd ed., Manchester University Press, Manchester and New York, 1997, p. 280. For some, such thinkers have very little to contribute to any analysis of the 'real world', du Plessis, 'International Relations Theory and the Discourse on Terrorism', p. 140. And some even go to the extent of suggesting that 'If relativism is consistently applied it will destroy traditional scholarship; but it will also destroy its own foundations', Knutsen, A *History of International Relations Theory*, p. 280.

[71] Michel Foucault, *Discipline and Punish: The Birth of Prison*, trans Alan Sheridan, Penguin, London, 1977, p. 23. On the relationship between power, knowledge and science also see ibid., pp. 295-6.

[72] Murielle Cozette, 'Reclaiming the Critical Dimensions of Realism: Hans J. Morgenthau on the Ethics on Scholarship', *Review of International Studies*, vol. 34, no. 1, 2008, p. 8. It is an important point but nonetheless, and from a paradigmatic viewpoint, it is important to stress the qualitative difference in the use of the word. Critical for critical theorists operates (or should) at the meta-theoretical level. Taking this into consideration, Neufield writes, 'It is interesting to consider how the interest of mainstream social science stands in relation to metatheoretical discourse. If it is true that metatheoretical critique is necessary to

The second approach that is not dealt with at length is scientific modelling. The irony here is that it is post-modern and post-structural criticisms of this method of research that are most scathing. Paul Cilliers argues that:

> We cannot make simple models of complex systems. Their nonlinear nature, or, in other words, their incompressibility, demands that the model of a system be as complex as the system itself. If it is in the nature of the system to behave, at least sometimes, in novel and unpredictable ways, the model must also do so. In any case, how would we be able to determine if the model were an adequate model of the system if we were already in trouble when trying to decide what constitutes the system itself? It would be as difficult to interpret the model as to interpret the system itself. Good models of complex systems can be extremely useful; I just do not believe that they will allow us to escape the moment of interpretation and decision.[73]

However, modelling remains an important research tool for complexity theorists. It is the development of the computer that has allowed advanced modelling techniques to reveal hidden patterns as to how 'nature works'.[74] However, problems immediately emerge when attempting to *apply* complexity theory to real world situations. Abstracting anything is always problematic, but not least of all in a complex system that, by its very nature, relies on interactions between multiple and diverse agents who push and pull, create and evolve, and drive structures that then feed-back in a true dialectical manner. John Holland is well aware that determining the 'utility of a given activity' is difficult as the 'utility of the various

---

challenge mainstream theorizing at the most fundamental level, then is it any wonder that so many mainstream theorists seem intent on inculcating new generations of social scientists with the strongest possible antipathy to metatheory? And who can doubt that the theoretical mainstream has been extremely successful in this regard? How else to explain the widespread hostility to all things metatheoretical? How else to account for the neglect of – and even the barely disguised impatience with – metatheoretical discussions even within the work of those with an explicit commitment to critical enquiry?' Mark Neufield, 'What's Critical About Critical International Relations Theory?' in Richard Wyn Jones, ed., *Critical Theory and World Politics*, Lynne Rienner Publishers, London and Boulder, 2001, p. 144.

Paul Cilliers, 'What Can We Learn From a Theory of Complexity', *Emergence*, vol. 2, no. 1, 2000, p. 31. Also as Byrne argues 'Agent-based simulation can generate emergent structure but in the real social world structure is the product not just of contemporary actions but of history. It is there as we act although our actions constitute and change it. In other words, a simulation that would be adequate a representation of the social complex cannot start from agents alone.' Byrne, 'Complexity, Configuration and Cases', p. 103.

[74] See, for example, Benoit B. Mandelbrot, *The Fractal Geometry of Nature*, rev. ed., W.H. Freeman and Company, New York, 1983 [1977].

activities of a given agent depends too much on the changing context provided by other agents'.[75] To add further fuel to the fire, Holland also concedes that a 'computer based model is already an abstraction from data' and most importantly it is not 'automatically constrained by physical reality'.[76] In attempting to overcome this, and acknowledging that a level of reduction (as opposed to Newtonian/Cartesian reductionism) will always occur, Holland draws attention to his new paradigm by stating that:

> Model building is the art of selecting those aspects of a process that are relevant to the question being asked. As with any art, this selection is guided by taste, elegance and metaphor; it is a matter of induction rather than deduction. High science depends on this art.[77]

Critically, 'man-the-scientist' is more readily making admissions of the interpretive and arbitrary nature of model building, much in the same way that 'man-the-artist' has arguably known for millennia[78] that what is revealed is a reconstruction of reality that gives an impression of what is knowable (an idea that a Romantic like William Blake would almost certainly agree with). This is also made evident by Holland's own admission that attempts to measure a complex adaptive system[79] even when this is done 'with a careful research plan, under

---

[75] Holland, *Hidden Order*, p. 97. From this, Morel and Ramanujam argue, a weakness of the study of complex adaptive systems becomes apparent in that 'as a paradigm for understanding self-organization is that the adaptive behavior of the agents is an input, and the physics of the self-organization is buried in the assumptions'. Benoit Morel and Rangaraj Ramanujam, 'Through the Looking Glass of Complexity: The Dynamics of Organizations as Adaptive and Evolving Systems', *Organization Science*, vol. 10, no. 3, Special Issue: Application of Complexity Theory to Organization Science, 1999, p. 281. They continue, interestingly: 'Seen from the perspective of physics, self-organization requires a mix of conditions like being out of equilibrium … and the dynamic possibility of building new stable dynamic units made from the aggregation of several components. The adaptive nature of the agent is what a physicist would like to "explain," not assume.'

[76] Holland, *Hidden Order*, p. 96 Holland adds, '[t]he experimenter can impose any computable laws, and they can be as fanciful as desired or accidentally permitted.' In his defence Holland argues the importance of the need for a 'correspondence principle' to well-established theories in order to halt flights of fancy. ibid., p. 171.

[77] ibid., p. 146.

[78] Benoit Mandelbrot makes this valid (yet gendered) point. Benoit B. Mandelbrot, 'Fractal Geometry: What is it, and What does it do?', *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences*, vol. 423, no. 1864, 1989, p. 9. It is elaborated upon in Chapter Two and at the end of Chapter Five.

[79] The complex adaptive systems are very much viewed as a cornerstone of complexity theory. See Chapter Three.

controlled conditions, using selected agents' that 'complex adaptive systems do pretty much as they damn please'.[80]

In light of this, it should not be forgotten that the use of mathematical models is always accompanied by difficulties, and those seeking a complexity-based understanding of the world must acknowledge the epistemological and ontological foundations upon which any such modelling is built. Dynamic processes should not become the new Newtonian application, and the emerging mathematical models should not be the new 'black box' where 'an act of faith is needed to believe its "predictions"'.[81] Indeed, Stephen Lansing points to the work of anthropologist Stefan Helmreich, who has certain difficulties accommodating models of artificial societies, as they 'reflect the unconscious cultural assumptions and social prejudices of their creators'.[82] Quoting directly from Helmreich, he adds that:

> Because Artificial Life scientists tend to see themselves as masculine gods of their cyberspace creations, as digital Darwins exploring frontiers filled with primitive creatures, their programs reflect prevalent representations of gender, kinship, and race and repeat origin stories most familiar from mythical and religious narratives.[83]

It is at this junction that social scientists need to be wary so as to avoid accusations of indulging in 'bandwagon science,' which is basically the over-enthusiastic rush

[80] Holland, *Hidden Order*, p. 96.

[81] Morel and Ramanujam, 'Through the Looking Glass of Complexity', p. 290. In looking at international relations from the perspective the cyclical ebb and flow of hegemons, Jervis quit rightly acknowledges difficulties in factoring a state's behaviour and the expected behaviour by another as constant. A criticism that can all too often be directed game theory. Robert Jervis, *System Effects: Complexity in Political and Social Life*, Princeton University Press, Princeton, 1997, pp. 85-6. To a point game theory can accommodate such complications, however, basically a linear and additive understanding 'cannot capture what happens because the impact of one variable or strategy depends on others as actors both shape and are shaped by their environments' (p. 91).

[82] J. Stephen Lansing, 'Complex Adaptive System', *Annual Review of Anthropology*, vol. 32, no. 1, 2003, p. 200.

[83] Stefan Helmrich quoted in ibid. Helmrich also offers a warning in that 'the use and abuse of computer simulations bears watching – especially in situations where there is notable power differential between those putting together the simulation and those whose lives are the subjects and objects of these simulations.' ibid pp. 200-1.

to whatever new scientific theory flows into the popular realm.[84] Indeed, it is because of this rush that the transference of these ideas have developed an enormous breadth. On the one hand, post-modernists have discovered 'an elegant theoretical envelope for the grounding of postmodern social policy and practice.' Stability and control is modernity, and can be easily enough linked to the technological advance that was underscored by traditional science;[85] non-linear science can be seen to offer an alternative narrative base. On the other hand, there are those who follow an idea of science that better reflects positivist assumptions, irrespective of their non-linear bent. Vicean criticism can certainly be levelled at the 'mathematical rigor' that some social scientists seek to apply when transferring chaos theory, as they imagine it, from natural sciences to the social.[86]

Before turning to the thesis outline, it is worth reflecting that complexity theorists are themselves sometimes guilty of wishing that there existed a hardened notion of social science law-making. Stuart Kauffman, in his desire to displace Newtonian dominance, has stated that he would like to see the development of general laws of life – laws that he places as 'contingent, unpredictable, and accidental'.[87] Throughout his work, he continually asserts his *belief* that 'such laws can be found', built upon the *hope* that they will reveal a 'theory of emergence'.[88] Further, Kauffman concludes, and quite troublingly so, that he believes that 'laws' of social evolution can be discovered.[89] It is the use of the word law, and the deterministic idea it entertains, that is particularly unhelpful. There is sufficiently more to be

[84] K. Michael Mathews, Michael C. White and Rebecca G. Long, 'Why Study the Complexity Sciences in the Social Sciences', *Human Relations*, vol. 52, no. 4, 1999, p. 449. Although not entirely contained to the 'natural/social' scientific divide, Kauffman contends that even seeking a deep structure in biology has been described as 'physics envy', Stuart A. Kauffman, *The Origins of Order: Self-Organization and Selection in Evolution*, Oxford University Press, New York, 1993, pp. 643-4.

[85] T.R. Young, 'Chaos Theory and Social Dynamics: Foundations of a Post modern Science' in Robertson and Combs, eds., *Chaos Theory in Psychology and the Life Sciences*, Lawrence Erlbaum Associates, New Jersey, 1995 pp. 219-20.

[86] Elliot and Kiel, 'Introduction' in *Chaos Theory and the Social Sciences*, pp. 2-3. Further to this those looking for answers from chaos or complexity theory should take heed from warning that the scientific imagination of the twentieth century is littered with 'a long line of 'highly mathematical theories of almost anything'', John Horgan quoted in Lansing, 'Complex Adaptive Systems', p. 200. Vicean thought relates to the work of Giambattista Vico as outlined in the following chapter.

[87] Stuart A. Kauffman, *At Home in the Universe: The Search for Laws of Self-Organization and Complexity*, Oxford University Press, Oxford and New York, 1995, p. 19.

[88] ibid., pp. 22-23.

[89] ibid., pp. 299-301.

gained by resorting to looser explanations that openly acknowledge that what are being dealt with are idealizations[90] that are built upon interpretive pattern recognition. It is here that complexity theory continues to fall down for those studying social systems. When evoking complexity theory, scholars of IR have to stop 'making assumptions about actors, their decision-rules' and feedback effects, in the hope that their modelling of some simplified component of the international system will allow them 'to see if they can "grow" the phenomena or property'.[91] Basically, when examining the phenomenology of such non-equilibrium behaviour it is necessary to remember that the associated phenomenon exceeds the abilities of any 'theoretical apparatus' to adequately cope. Instead, the emphasis needs always to be on looking for some level of generalisation.[92]

Thesis Outline

To move back into the realm of IR theory, Samuel Huntington, in his controversial work *The Clash of Civilizations*, argues the importance of theory when he, quoting Gaddis, suggests that '[f]inding ones way through unfamiliar terrain generally requires a map of some sort. Cartography, like cognition itself, is a necessary simplification that allows us to see where we are, and where we may be going'.[93] The argument is that there is a need for tools, models, metaphors, and in his case (to use the term loosely) paradigms to simplify a highly complex situation into a manageable generalisation. Huntington justifies his position by continuing the cartographic example, in which he explains the need for a simplified map if one is travelling between major cities. If one were to instead examine a detailed map, the major highways would become lost in a mass of secondary roads.[94] Thomas Kuhn, the philosopher of science, in a similar vein concedes that:

---

[90] See ibid., p. 75.

[91] Earnest and Rosenau, 'Signifying Nothing?', p. 148. Moreover, modelling creates theories of process not politics. ibid., p. 149.

[92] Philip W. Anderson, 'Physics: The Opening to Complexity', *Proceedings of the National Academy of Sciences of the United States of America*, vol. 92, no. 15, 1995, pp. 6653-4.

[93] Samuel Huntington, *The Clash of Civilizations and the Remaking of World Order*, Touchstone Books, New York, 1996, p 30.

[94] ibid., p. 31.

> information provides a map whose details are elucidated by mature scientific research. And since nature is too complex and varied to be explored at random, that map is as essential as observation and experiment to science's continuing development.[95]

Huntington, whose thesis illustrates startling linearity in its additive conclusion, is nonetheless correct in the assertion of the need to reduce. However, the error that he and many others commit is to do so in a manner that does not accept the realities of emergence, that the integrity of the whole is undermined when reduced to composite parts. And mixed into the equation (a non-linear one, of course) is the knowledge that 'paradigms provide scientists not only with a map but also with some of the directions essential for map making'.[96] Here the dance between ontology and epistemology continues ever after, a distinct sub-theme throughout the thesis.

With that in mind, the structure of the thesis is as follows. Five chapters build around the central argument that complexity theory has not been properly incorporated into the study of international relations, and that its underlying assumptions and development have not been fully explored in the international relation literature. It is argued that this is not about a new methodological approach, but a meta-theoretical commitment to an alternative paradigm that may assist further theory-building. Overall, the argument is made that a non-linear *paradigm* will preserve the importance of intuition and interpretation to the study of international relations, but it will do so without being deemed irrelevant for lack of a scientific base, or be accused of 'physics envy' because of its scientific base.

The first chapter begins by arguing that the idea of science and the positivist position that emerged from the Enlightenment misinforms supporters and critics of approaches within the social sciences. The argument stresses the need to move

---

[95] Thomas S. Kuhn, *The Structure of Scientific Revolutions*, (International Encyclopaedia of Unified Science, vol. 2, no. 2) University of Chicago Press, Chicago, 1962, p. 109.
[96] ibid., p. 109.

away from the reductionism of the Newtonian paradigm. Treated in detail is the work of Thomas Kuhn. This is done in order to build an argument of the inherent historicism of science and the manner in which paradigms inform research across disciplines. Newton also receives close attention, as it would be inappropriate to build an argument in opposition to Newtonianism without engaging directly with his ideas. Of particular importance in the chapter is the acknowledgment that social science has been (and, less obviously, continues to be) informed by this dominant paradigm. Nowhere is this more evident than in respect to economics, which stands as the most 'scientific' of the social sciences.

The second chapter argues that chaos and order are a dichotomy that have defined human societies at the most essential level. The desire for order and linearity is imbued by the dominant scientific paradigm, driving the wedge of traditional science between the rational and the irrational. It is observed, via the introduction of chaos theory, that the rise of non-linear science has challenged this dichotomy and, with it, the scientific imagination. Beginning with Henri Poincaré, the prominent French physicist, and his famous three-body problem, the chapter looks at the undoing of Kepler's and Newton's neat orbits that generated the idea of a clockwork universe, and, from that, the mechanistic views of society, defined by simplistic and linear notions of cause and effect. Much later, the development of computer-generated fractals allowed for the visualisation of mathematics, in a manner that eroded Euclidean straight lines and Newtonian reductionism. What occurs is the realisation that the imagination of the scientist and the artist are not as distant as has often been depicted. Imagination becomes re-invigorated; allowing interpretation to resume its firm place, but doing so without abandoning what might be referred to as 'scientific rigour'.

The third chapter is the linchpin of the thesis, arguing for the introduction of six presuppositions to support the introduction of complexity theory as an alternative scientific paradigm. At the meta-theoretical level, these presuppositions permit the development of alternative ontological and epistemological assumptions to take root. The accepted fundamentals of what constitutes complexity theory are introduced and examined. This, it is argued, supports the concept of emergence being the central concept that captures why order will *always* emerge in a complex system. Moreover, such order, in *dynamical* systems, will push away from notional points of equilibrium. As an adaptive and holistic approach, it has the potential to reshape the scientific imagination, with the final presupposition stating that intuition is released from its positivist prison or, from the countervailing position, it can avoid the perceived slipperiness of unbounded reflectivism.

The fourth chapter argues that the preoccupation with order, anarchy and power in the study of international relations is a continuation of the desire to create theories that display order and neatness via simplification and reductionism. It is proposed that the Newtonian paradigm, however implicit it may be, and often transferred via an economic ontological understanding, skews images of global politics resulting in many rationalist-based theories searching for a theory of natural equilibrium. The idea of a natural equilibrium, a natural point of return, in an anarchic system is shown to have become a discipline-defining concept. Bearing the authority of science and trading on the privilege associated with laws permitted a linear and predictable (in a broad sense) conceptualisation of world politics. A complexity-inspired understanding counters this by establishing that social systems are far-from-equilibrium enterprises.

The final chapter argues that the international system is nested in nature, with multiple complex adaptive systems present. The dialectic between structure and agent similarly define the nature of any given system. Dominant points of attraction, like the state, occur, as too do dominant processes, as in the case of globalisation (both of which are multi-dimensional). The argument concludes that a non-linear understanding will support theories of international relations so long as they surrender positivist assumptions of linearity, reductionism, predictability from additive conjecture, and the belief that intersubjective relationships are of little relevance. Put in another way, it is the concept of emergence, the idea that the whole is more than the sum of the parts, that is offered by this new 'turn'. With caution, new avenues of exploration open up when it is realised that:

> Many of the great mysteries of science are emergent phenomena. Mind, consciousness, biological forms, social structures – it is tempting to leap to the conclusion that chaos and complexity hold the answers to these mysteries. However, at least as currently conceived, they do not and cannot. The role of chaos and complexity has been crucial and positive: they have caused us to start asking sensible questions and to stop making naïve assumptions about the source of complexity or pattern. But they represent a tiny first step along a difficult path, and we should not let ourselves be carried away by over ambitious speculations based on too simple a notion of complexity.[97]

A complex theory of international politics or an international theory of emergence, if either should emerge, would embrace the uncertainty that derives from accepting that social systems can be explained and understood via the lens of non-linear science. By turning to this paradigm as a means to support underlying assumptions about the social, the limitations for concrete claims are very quickly exposed. The international system, in this light, should be understood as a series of complex adaptive systems, and any attempt to attach importance and value to any point within the system(s) over another should be recognised as an arbitrary and reductionist process. Of course, the application of a non-linear approach cannot escape reductionism, but it can strive to be less reductive, with its significance coming from the *knowledge* that being reductive and arbitrary distorts and constitutes, at some level, the nature of what is being studied. Further, it is the acceptance that emergence is a fundamental principle within social systems that prohibits any attempt to devise a universal model that seeks to explain any system in its entirety. Thus, in many respects a full circle is made. Science was used to define the social through the advances of the Scientific Revolution and a good number of thinkers of the Enlightenment. Those who felt it did not capture what it meant to be human rejected this approach; science moved on, yet culturally and

[97] Ziauddin Sardar and Iwona Abrams, *Introducing Chaos*, Icon Books, Cambridge, 1999 [1998], p. 171.

socially it did not. If theories of IR can draw from this new meta-theoretical base, then interpretation and intuitive understanding are returned to the fore, and without neglecting, or being separated from, important research in the hard and natural sciences.

1

Defying Newton: Beyond Scientific Reductionism

Nature and Nature's laws lay hid in night;
God said, 'Let Newton be' and all was light[1]

The idea that the natural sciences continue to inform IR theorists is not new, but the thesis argues that it is the monolithic understanding as to what science represents at the meta-theoretical level that misinforms supporters and critics alike. Essentially, this can be understood in terms of the social sciences continuing to replicate the 'traditional' scientific outlook that emerged from the Scientific Revolution and the Enlightenment (the positivist position of a world that can be understood and explained by science). However, by tracking the development of this rationalistic understanding of world affairs it is suggested that for science to

[1] Alexander Pope, 'Epitaph intended for Sir Isaac Newton' in Daniel Stempel, 'Angels of Reason: Science and Myth in the Enlightenment' *Journal of the History of Ideas*, vol. 36, no. 1, 1975, p. 64. See also Bertrand Russell, *History of Western Philosophy*, 2nd ed., Unwin University Books, London, 1961, p. 523.

remain relevant to the study of social systems a Kuhnian-like paradigm shift is required. Thus, through a broad overview of how the roles of science and natural philosophy have underscored the development of IR theory, it is argued that complex notions of social interactions are 'reduced' by the prevailing meta-theoretical understanding. Strictly positivist methods, stemming from 'traditional' science, have to give way, or, at very least, accommodate the 'new' thinking emerging from the non-linear sciences. The difficulty in this approach lies in not slipping too far down the reflectivist slope, as the intention is not to give way to an unabashed relativist position, but to illustrate that science and notions of truth can still inform those wishing to apply a meta-theoretical foundation that incorporates a substantive understanding of the world.

In following this argument, the chapter proceeds in four stages. First, drawing on Thomas Kuhn, it develops the concept of paradigms as a means of explaining how scientific knowledge is contained and constructed. Second, it introduces elements of Sir Isaac Newton's *Philosophiæ Naturalis Principia Mathematica* (hereafter referred to as the *Principia*) that defined his revolutionary new world, but, importantly, also reflects on the historical and cultural impact of his work. Third, the chapter argues that the ascent of a rationalistic understanding of the world was (and, in a more subtle guise, continues to be) implicitly and explicitly shaped by 'Newtonianism'[2] (and the earlier influence of René Descartes). Finally, it looks at how examining and thinking about the social realm became, and, with qualification, was defined by this dominant scientific outlook. At its heart, the chapter establishes that science is bound, and defined, by dominant paradigms. It is paradigms that frame the ontological and epistemological basis of what there is to be studied, and how it should be studied. From this, it is argued that the formation of a Newtonian

[2] As Alexandre Koyré points out: 'all of us, or if not all still most of us [speaking very much from the Western perspective], have been born and bred – or better and more exactly, not *born* (as this is impossible) but only *bred* – in the Newtonian or, at least, a semi-Newtonian world, and we have all, or very nearly all, accepted the idea of the Newtonian world machine as the expression of the true picture of the universe and the embodiment of scientific truth – this because for more than two hundred years such has been the common creed, the *communis opinion*, of modern science and of enlightened mankind'. See Alexandre Koyré, *Newtonian Studies*, The University of Chicago Press, 1965, p. 4.

paradigm resulted in the privileging, in varying degrees, of the inherent axiomatic, linearity and reductionism[3] that best describe the outlook. Consequently, social knowledge and the way in which human societies are imagined became increasingly defined by dominant scientific paradigms.[4] The chapter concludes by noting the need to examine how different ideas of science are beginning to places pressure on the continued (often implicit) supremacy of a Newtonian-inspired reductionist understanding of the world. Of course, Newtonianism is not a spell under which all fell. The objections of counter-Enlightenment thinkers, such as Giambattista Vico, or the Romantics (for example, William Blake), will be outlined.

Ultimately, the chapter charts the dominance of reductionist and linear methods of analysis within Western scholarship. It is argued that much of what emerged during the Scientific Revolution[5] and the Enlightenment led, in many respects, to assumptions as to the centrality of human rationality, universal laws, predictability and order.[6] Yet, whilst acknowledging the successes of linear-based theories, this chapter seeks to illustrate how this dominant outlook reflects a culture of science that self-reinforces and homogenises attempts to 'think' differently. This is not to suggest that thinking 'differently' is removed or disallowed (if anything scientific research encourages boundary pushing of known knowledge), but it is how parameters of accepted foundations control research agendas and thus, by extension, flow on and effect what is real and what

[3] Reductionist arguments are those based on first principles that enable the whole to be understood in an additive fashion.

[4] This is especially true of nineteenth century positivism (whish is discussed at length below).

[5] Hebert Butterfield can be said to have 'introduced the idea of a scientific revolution' in a 1948 lecture and, in Butterfield's words, it 'outshines everything since the rise of Christianity and reduces the Renaissance and Reformation to the rank of mere episodes, mere internal displacements within the system of medieval Christendom'. According to Butterfield, in this episode lay 'the real origin of both the modern world and the modern mentality'. Peter Harrison, 'Was there a Scientific Revolution?', *European Review*, vol. 15, no. 4, 2007, p. 445. Butterfield's thesis is easily reconciled with Thomas Kuhn's appreciation of what (dominant) science is (as discussed later in the chapter). Indeed, his use of historical examples marries well to Butterfield's historical construction as Kuhn is primarily concerned 'with the kind of change that took place in the classical physical sciences in the seventeenth century, and in chemistry in the eighteenth', Andrew Lugg, 'Review Essay: Kuhn and the Philosophy of Science', *The British Journal for the History of Science*, vol. 12, no. 3, 1979, p. 291.

[6] Robert Geyer makes a similar claim in 'Globalization, Europeanization, Complexity, and the Future of Scandinavian Exceptionalism', *Governance: An International Journal of Policy, Administration, and Institutions*, vol. 16, no. 4, 2003, p. 564.

is worth knowing at a societal level. This is less about what is real (say, the existence of a table) but more about the means to explain what axioms, how they relate to one another, and how they are used to construct an explanation of reality. This chapter begins the process; it sets the scene of documenting linear Newtonian determinism so that the movement toward non-linear approaches can be appreciated.[7] Revealed is the extent of the positivist influence of Newtonian-based principles in the realm of social enquiry.[8]

Abstracting the World – Long-Held Traditions

The social sciences have, in many respects, sought to replicate the successes of what Kuhn refers to as the 'mature' sciences.[9] The roots of this positivist tradition, of which Descartes and Newton can be considered meta-founders,[10] focuses on the simplicity of cause and effect of material factors, and suggests a certain level of predictability. Approaching their legacy from a Kuhnian perspective supports the argument that as meta-founders they shaped a mode of enquiry that reached it primacy in the 19th century with the emergence of thinkers like Auguste Comte, Ernst Mach[11] and Karl Marx. Although 'hardest' (that is, at its most extreme and defined) during the nineteenth century, it will be illustrated in this and following chapters that this paradigmatical pressure predates the nineteenth century in respect to how science and the social were imagined, and continued beyond into the twentieth.[12] Its influence continues but there exists a variety of competing paradigms (the notion of incommensurability is dealt with at a later stage) whose ascendancies have challenged scientific transference to the social realm, most

[7] Chapters two and three work towards that goal.

[8] See, for example, Alexander Wendt, 'Why a World State is Inevitable', *European Journal of International Relations*, vol. 9, no. 4, 2003, p. 494.

[9] Kuhn, *The Structure of Scientific Revolutions*, p. 11.

[10] Meta-founders in the sense that their work informed the creation of the positivist school. The term positivism was not coined until the nineteenth century. Joyce Appleby, Lynn Hunt and Margaret Jacob, *Telling the Truth About History*, W. W. Norton & Co., New York 1994, p. 67

[11] Koyré, *Newtonian Studies*, p. 64. See also Bruce Caldwell, 'Positivist Philosophy of Science and the Methodology of Economics', *Journal of Economic Issues*, vol. 14, no. 1, 1980, pp. 53-76.

[12] In IR theory its influence is exerted post-Second World War, incorporated, one way or another, in the second and third so-called 'great debates'. See, for example, Alexander Wendt, 'On Constitution and Causation in International Relations', *Review of International Studies*, vol. 25, no. 5, pp. 101-118. Indeed, the behaviouralism that dominated the development of IR theory in the post-World War II period is indicative of the strength of this paradigm. See Gaddis, 'International Relations Theory', pp. 12-13.

notably from relativist-based theories. Consequently, a further challenge is to highlight the contextual nature of objectivity, but doing so without surrendering to unabashed relativism. Empirical evidence and accepted norms are vital in assisting our understanding of the world, and also our understanding of the international system.[13] However, to displace, or, more appropriately, to re-imagine how science frames debates beyond its arbitrary disciplinary boundaries requires an analysis of what traditional science is.

The 'father of nuclear physics',[14] Lord Earnest Rutherford, in pursuing scientific truths, had strong opinions as to what constituted proper scientific endeavours. His frequently-quoted proposition that 'All science is either physics or stamp collecting'[15] captured an essentialism felt within the 'hard' sciences. An irreverent attitude, perhaps, but he further qualified his remark by suggesting that '[q]ualitative is nothing but poor quantitative',[16] so arguing that interpretive methods that could not break down their subject area so that they might expose the true nature of things basically lacked scientific rigour. This attitude is symptomatic of not only scientific approaches that emerged out of the Enlightenment, but, in time, how scholars would study and, ironically, interpret the social realm. The flow-on effect is entrenched in the reductionism of Newton, and it is a focal point. Newtonianism is the idea, the node that connects the swirl of conjecture around the concept of scientific and linear reductionism. Yet it is equally important to stress that the desire to discover underlying truths, and the fixation on reducing to simplicity, extends far beyond Newton (as the story of traditional science's hold over how knowledge is known extends well beyond a single man), with thinkers extending back to the ancient Greeks seeking

[13] There, of course, lies an interesting relationship between 'empirical evidence' and 'accepted norms' that is bound by prevailing paradigms.
[14] See Robert Robinson, 'Address of the President Sir Robert Robinson, at the Anniversary Meeting', *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences*, vol. 205, no. 1080, 1950, p. 12.
[15] Bruce J. West and Bill Deering, *The Lure of Modern Science: Fractal Thinking,* World Scientific, Singapore, 1995, p. 14
[16] ibid.

mathematised abstractions that secured absolutes and kernels of truth. Such abstractions allowed the world to be axiomatically appreciated.[17]

The influence of the axiomatic geometry of Euclid serves as a useful example of the desire to discover underling truths, as it not only allowed for the construction of scientific approaches built upon 'self-evident axiom[s]', but some philosophers even attempted to reconcile their own positions with the mathematical success of such approaches.[18] Euclidean geometry was thought to describe the world as how it was, and not as a construct or a close approximation, with Descartes, for one, 'th[inking] of himself as the Euclid of physics'.[19] It is pertinent to note that while such linkages give a deliberately selective account about the 'rediscovery' and privileging of geometric absolutism, there is no doubt that there have existed many philosophers and thinkers who did not fall under any such spell. For example, one need only consider the Stoic tradition as an alternative that occupied a period between Euclid's revelations and the onset of the Scientific Revolution. Stoicism advanced the primacy of judgment for the interpretation and construction of understanding; Cicero, as one scholar points out, stressed that 'the logic of the Stoics is limited to judgment'.[20] Yet the Euclidean connection did represent, after a lengthy gestation, a general movement towards a new paradigm that captured the scientific and philosophical imagination. The Scientific Revolution offered the opportunity for absolute truth and scientific maxims to be used, and the promotion of a view that a 'real' understanding of the world may be built. This, in turn, pervaded philosophical argument, and is especially evident in

---

[17] Descartes, for one, accepted the 'fundamental construction postulates of Euclid', Mary Domski, 'The Construction and the Intelligible in Newton's Philosophy of Geometry', *Philosophy of Science*, vol. 70, 2003, p. 1115.

[18] John D. Barrow, *Impossibility: The Limits of Science and the Science of Limits*, Vintage, London, 1999 [1998], p. 42. And also that of Archimedes. ibid.

[19] G. A. J. Rogers, 'Descartes and the Method of English Science', *Annals of Science*, vol. 29, no. 3, 1997, p. 240.

[20] Richard McKeon, 'Philosophy and the Development of Scientific Methods', *Journal of the History of Ideas*, vol. 27, no. 1, 1966, p. 9. Further, much else defined philosophical approaches within the 'arts'; 'The development and use of the liberal arts during the Middle Ages had a basis in the practical and legal tradition-Ciceronian rhetoric, Platonic dialectic, Stoic morals, and a small part of Aristotle's logic, the *Categories* and *On Interpretation*. They were arts for the examination of *ways, reasons,* and *modes* of words and things, *verba* and *res* - discourse, problems, and facts. During the early Middle Ages the word *methodus* was not used…', ibid.

the work of Baruch Spinoza, who represented the more extreme end of scientific appropriation, whose 'philosophical propositions was even laid out like the definitions, axioms, theorems, and proofs in Euclid's works'.[21] For Spinoza the 'laws of nature' applied to man, and man behaved accordingly. At this level, therefore, the privileged position of science can be seen to have leeched through the Western imagination.[22] Mathematics was to become the language of science, and its development can be seen as a fundamental part of appropriate methods of reducing so as to assist with constructing appropriate models of understanding. With the ascendency of mathematics and science, rooted in the demystification of the world around, surfaced the tendency to generate absolutes and objectivity, thereby laying the groundwork for rationalism:

> Early mathematics has [had] a central role in western intellectual history. It had a major influence on philosophers from Plato and Aristotle down to, say, Spinoza, Leibniz, or Kant, so that it shaped the very modern notions of truth and rationality. And because of its seminal role for modern science, it to a large extent shaped the direction of the modern exact sciences as well. At least until the very last decades, modern science was organized as a system with mathematical physics at its center – indirectly, then, based on a certain perception of Archimedes – mathematics itself understood on the perceived model of Euclid's axiomatic system. In short, our understanding of the nature of early mathematics – and in particular of the major works of Euclid and Archimedes – should also define our understanding of the nature of science and of rationality themselves. After all, the ideal of Euclid was created by philosophers, the ideal of Archimedes was emulated by scientists, precisely because these were perceived as being impersonal and ideally objective.[23]

[21] Barrow, *Impossibility*, pp. 42-3. Consider also that by 'early modern times the geometric framework of postulates, definitions, and derived theorems structured the presentation of works as diverse as Newton's Principia and Spinoza's Ethics. Even at that time, Descartes recognized the geometric method as better suited for presentation of a subject already understood than as a method of discovery', Merrilee H Salmon, 'Reasoning in the Social Sciences. *Syntheses*, vol. 97, 1993, pp. 252-3.

[22] John Plamentatz, *Man and Society: A Critical Examination of Some Important Social and Political Theories from Machiavelli to Marx*, vol. 1, Longman Group, London, 1963, p. 79.

[23] Reviel Netz, 'Introduction: The History of Early Mathematics – Ways of Re-Writing', *Science in Context*, vol. 16, no. 3, 2003, pp 278-9.

It is important to realise that this is far from being a one-sided affair. The establishment of mathematics as a means for abstraction and exploring concepts not easily described has had important ramifications for societies-at-large. Further, the notion of 'reductionism' has not always gone unchallenged, the Aristotelian notion of the whole being more than the sum parts predating any concept of emergence that any complexity theorist may claim as an original thought. By noting what complexity theorists[24] might refer to as the 'computational irreducibility'[25] of the whole, Aristotle countered one of the Zeno's, the pre-Socratic philosopher, famous paradoxes. Jeffrey Goldstein summarises Zeno's paradox:

> Zeno insisted that a distance of any length could be divided into an infinite number of shorter segments. This meant that covering the distance required traversing an infinite number of shorter segments, a rather absurd notion given that "we obviously do cross distances in finite lengths of time!" Aristotle's answer to Zeno was that a length was first and foremost a whole. True, the whole might be divided into an infinite number of parts – nevertheless, the whole was fundamentally irreversible to those parts. In fact it was only because a distance was a "whole before its parts" that it could be traversed. [26]

This underlying principle, the Aristotelian idea that the whole is not equal to the sum of the parts,[27] lays the groundwork so that how the international system is thought to function, with its multiple actors across multiple levels, can be conceptualised non-reductively. To accept this is a starting point requires the acceptance of a different idea of truth than of that bounded in the reductionist axioms of classical scientific rationality.

[24] See, for example, Kauffman, *At Home in the Universe*, p. 24.
[25] Stephen Wolfram, *New Kind of Science*, Wolfram Media, Champaign, 2002, p. 750.
[26] Jeffrey Goldstein, 'Emergence as a Construct: History and Issue', *Emergence*, vol. 1, no. 1, pp. 51-52.
[27] See Chapter Five.

Paradigms Revisited

Truth often presents itself as a significant stumbling block for theorists who wish to build their theoretical musings upon a solid foundation. Etymologically, the word descends from an idea of faithfulness and fidelity; notions of loyalty pervade its Indo-European roots. Much later, towards the end of the 16th century, its meaning became fixed upon notions of what is correct or accurate.[28] Curiously, this was the same period in which the Scientific Revolution, the backbone of the Enlightenment, commenced. Consequently, and with the passing of time, the definition became more rigid. Grammatically, those wishing to loosen its definition have resorted to either the use of an indefinite article or pluralising the term – it is not uncommon to now be told of there being 'a truth' or 'many truths'. For the purpose of establishing the ontological presuppositions upon which the overall argument is built, a linguistic turn is needed; an extended debate as to nature of truth is not the intent here. Instead, a definitional abandonment in favour of a different root is suggested. Alethia (ἀλνθὑξ), the Greek word for truth, translates as 'uncover' or 'unconcealment',[29] and, further, sits comfortably with the Habermasian notion of truth being a validity claim.[30] Through exploration, a consensual understanding can be uncovered that offers a dominant understanding of the world, whilst at the same time still allowing for a level of differentiation. Effectively, this is an argument for the acceptance of nested truth. Multiple 'truths'

---

28 The earliest recorded date of such a usage is 1570. See Oxford English Dictionary, Oxford University Press, online at: http://dictionary.oed.com/cgi/findword?query_type=word&queryword=truth, accessed 15/09/06.

29 Drawn from Heidegger in Patrick A. Heelan and Jay Schulkin 'Hermeneutical Philosophy and Pragmatism: A Philosophy of Science', *Synthese*, vol. 115, no 3, 1998, p. 284. See also Ramsés Fuenmayor, 'The Roots of Reductionism: A Counter-Ontoepistemology for a Systems Approach', *Systems Practice*, vol. 4, no. 5, 1991, p. 428.

30 Anthony Giddens, 'Jürgen Habermas', in Quentin Skinner, ed., *The Return of Grand Theory in the Human Sciences*, Cambridge University Press, Cambridge, 1985, p. 130. See also Karl-Otto Apel, 'The Hermeneutic Dimension of Social Science and its Normative Foundation', *Man and World*, vol. 25, no. 3-4, 1992 p. 252. Birgit Locher and Elisabeth Prügl capture the essence of Habermas' argument stating 'that knowledge is constructed through interactions of subjects who negotiate in communicative exchanges common definitions of the world. Interpretations of reality come about through a communicative affirmation or challenge of validity claims. Knowledge is always produced in specific social and historical contexts, reflecting the interests and culture of the groups in question. What counts as knowledge can be assessed against standards of rationality but is ultimately tied to a particular social and historical location.' Birgit Locher and Elisabeth Prügl, 'Feminism and Constructivism: Worlds Apart or Sharing the Middle Ground?', *International Studies Quarterly*, vol. 45, no. 1, 2001, p. 119.

may well exist, but dominant understandings are not negated simply because differing worldviews exist.[31]

Yet the counterpoint still draws attention to how difficult it is to approach knowledge when dealing with social systems, especially so when dealing with a whole consisting of a large number of constituent parts (i.e. the state). Certainly in the realm of IR theory, intersubjective notions hold considerable weight in terms of explaining how agents within a given system are constituted.[32] Of course, it remains possible to seek underlying truths by applying the lessons learnt from the 'traditional' sciences (which, in turn, can be and have been linked to scientific realism as a meta-theoretical base) so as to assure positivist foundations. The consequence of polarised debates is that, inevitably, bridge-building across the substantial theoretical space becomes a tempting option. Alexander Wendt is a prominent example of an IR theorist who attempts to find a balance between these approaches, yet essentially he is unable to halt his slide, via scientific realism,[33] down the path towards traditional reductionist science.

Accordingly, the dichotomy between what is asserted to be the reductionism and the positions held by relativist theories that lie in opposition, rests upon the foundational differences reflected in the subscription to or denial of the rationalist base. The polarised debate within IR theory is borne of the importance ascribed to

[31] This is despite the fact that such a term, to 'unconceal' (or uncover), would not alleviate opposing concepts as to the objectivity or subjectivity of what we know and how we should study it. Alexander Wendt, when discussing ontological and epistemological foundations of IR, raises this exact point. Alexander Wendt, *Social Theory of International Politics*, Cambridge University Press, Cambridge, 1999, p. 5. The position is bolstered by the argument that it was not the 'objectivity of science and the status of scientific truth' that was being undermined, instead it 'was a particular scientific claim about scientific truth' that was being challenged. John G, Gunnell, 'Realizing Theory: The Philosophy of Science Revisited', *The Journal of Politics*, vol. 57, no. 4, 1995, p. 927.

[32] This is especially true of IR scholars of constructivist leanings and English School approaches with their emphasis on normative considerations. Stephen D. Krasner, 'Rethinking the Sovereign State Model', *Review of International Studies*, vol. 27, no. 5, 2001, p. 22.

[33] Fred Chernoff, 'Scientific Realism as a Meta-Theory of International Politics', *International Studies Quarterly*, vol. 46, no. 2, 2002, p. 194; see also Neufield, 'What's Critical About Critical International Relations Theory?', p. 139. For a good critique of scientific realism see van Fraasen, Bas C., The *Scientific Image*, Clarendon Press, Oxford, 1980, passim.

a particular paradigm.[34] The authority and status endowed to a particular approach by scientists is what Kuhn refers to as a scientific paradigm, and it is argued that it is scientific paradigms that define which worldview assumes a dominant role (although it is equally important to remember that such delineation of knowledge represents a hierarchical division). The scientific outlook which becomes the pinnacle for understanding is what Kuhn refers to as 'normal science'. It is through this lens that the dominant research programmes are guided, and, crucially, it facilitates the way in which analogising occurs within it.[35] More so, '[n]ormal science' persistently strives to 'bring theory and fact into closer agreement',[36] with the ontological consequences of establishing what is worth knowing and the connected epistemological dilemma of how it is worth knowing. At the most basic of levels, agreement upon a particular worldview is quite impossible without a complete rationalisation and interpretation as to what constitutes 'a standard interpretation or an agreed reduction to rules'.[37] Kuhn uses the example of pendula to illustrate the how paradigmatic intent shapes the search for 'quantitative agreement between theory and observation'.[38] Attempting to reduce pendula, Kuhn noted are 'problems of the utmost difficulty'. The phenomenon of an object swinging from a string is not to be disputed by the observer. However, the science that explains it, and even names it as a 'pendulum', attributes the paradigmatic significance.[39] And, he adds, '[s]ince Newton's days much brilliant research has been devoted to their challenge.'[40] It is

[34] This claim is also true of most disciplines in the humanities and social sciences.
[35] Barry Barnes, 'Thomas Kuhn', in Quentin Skinner, ed., *The Return of Grand Theory in the Human Sciences*, Cambridge University Press, Cambridge, 1985, p. 87. Indeed, '[w]ithout commitment to a paradigm there could be no normal science', Kuhn, *Structure of Scientific Revolutions*, p. 100.
[36] Kuhn, *Structure of Scientific Revolutions*, p. 80. 'When Karl Popper discussed the normative description of scientific rationality, he was forced to admit that in the final analysis rational science owes its existence to its success ; the scientific method is applicable only by virtue of astonishing points of agreement between preconceived models and experimental results.', Prigogine and Stengers *Order Out of Chaos*, p. 5. Much later Prigogine and Stengers note the solidification of 'The academic structure in which the "normal science"', from the Kuhnian perspective, came into being took place in the nineteenth century.' ibid., p. 308.
[37] Kuhn, *Structure of Scientific Revolutions*, p. 44.
[38] Thomas S. Kuhn, 'The Function of Measurement in Modern Science', *Isis*, vol. 52, no. 2, 1961, pp. 169-70.
[39] Wes. W. Sharrock and Rupert S. Reed, *Kuhn: Philosopher of Scientific Revolutions*, Polity Press, Cambridge, 2002, pp. 52-4.
[40] Kuhn, 'The Function of Measurement, pp. 169-70.

this sentiment that imparts an importance upon theory construction as the process of and the need to became dominated by the Newtonian paradigm:

> Because physical science is so often seen as *the* paradigm of sound knowledge and because quantitative techniques seem to provide an essential clue to its success, the question how measurement has actually functioned for the past three centuries in physical science arouses more than its natural and intrinsic interest.[41]

The issue is that it develops a cultural and sociological edge, the influence of which can be seen throughout the social sciences. The post-World War Two behaviouralist turn in IR is an obvious example, but so too, more subtly, is the later neorealist movement.[42]

To unsettle, or indeed debunk, the dominant paradigm is difficult, as the assumptions upon which normal science is constructed will be defended vigorously, even to the point of suppressing novelties and anomalies, as they may subvert or undermine basic tenets.[43] Highlighted is the beginning of a process of divergence and suppression; from the initial emergence of the paradigm and its syncretic nature, to the point where anomalies become increasingly difficult to suppress. A community of scholars will not build entire careers from a paradigmatic viewpoint, and easily relinquish it upon the presentation of each and every new idea. For Kuhn, a new paradigm needs to be unprecedented to the

---

[41] ibid., p. 161.

[42] See Gaddis, 'International Relations Theory', passim. See also, in respect to neorealism Richard K. Ashley, 'The Poverty of Neorealism', *International Organization*, vol. 38, no. 2, 1984, pp. 225-86.

[43] Kuhn, *Structure of Scientific Revolutions*, p. 5. Kuhn states it as thus 'Though they may begin to loose faith and then to consider alternatives, they do not renounce the paradigm that has led them into crisis. They do not, that is, treat anomalies as counterinstances, though in the vocabulary of philosophy of science that is what they are.' ibid., p.77. Indeed, one can look at Newton's fourth rule of reasoning (that is dealt with at length below) to see an implicit example of a preparation for a paradigm defence when he states '…till such time as other phænomena occur, by which they may either be made more accurate, or liable to exceptions.' Isaac Newton, *Mathematical Principles of Natural Philosophy and His System of the World*, [1687], trans. Andrew Motte [1729], trans. Revised, and supplied with an historical and explanatory appendix by Florian Cajori, University of California Press, Berkeley, 1934, Book III p. 400.

extent that is attracts 'an enduring group of adherents away from competing modes of scientific activity'.[44]

A difficultly arises in reconciling what should happen if a competing view of the world challenge the dominant view, or, indeed, how it could even reach a position to challenge it at all. If the cultural significance of a particular view becomes so entrenched, how is it to be overturned? Students generally become members of the scientific community by successfully studying and accepting the worldview of the prevailing paradigm,[45] and consequently a paradigm becomes self-reinforcing and self-validating in the process of constructing what is true.[46] The problem of the dominance of a particular viewpoint is exacerbated, as the paradigm itself is neither tested nor judged. It is either used well, thus advancing knowledge, or it is used poorly, indicating incompetence at some level.[47] With this consideration, it becomes possible to regard the development of science as a cultural event, carrying with it the implication that it can be examined sociologically.[48] Science, therefore, becomes a complex mix of traditions, customs and established practices.[49] M.D. King expresses Kuhn's position in a succinct and deft manner:

> Scientific knowledge is not gained simply by escaping the spell of tradition and viewing the world 'objectively' or 'rationally. It comes from seeing the world from a particular point of view, or rather from a succession of points of view – each point of view

---

[44] Kuhn, *Structure of Scientific Revolutions*, p. 10. It must also be 'open-ended' enough so that it may 'leave all sorts of problems for the redefined group of practitioners to resolve' ibid.

[45] ibid., pp. 9-10. These can be considered the community's paradigms, revealed in its textbooks, lectures and laboratory exercises.', ibid., p. 43. Further, 'Textbooks or their equivalent are the unique repository of the *finished achievements* of modern physical scientists' [emphasis added], Kuhn, 'The Function of Measurement', p. 163.

[46] Barnes, 'Thomas Kuhn', p. 92. From this take the example that 'Many of the problems we now address are non-linear and chaotic, and defy our tried and tested mathematics. Curiously then, our education system still concentrates on feeding students a diet of linear problems with convenient closed-form solutions. Not surprisingly students form a picture of a universe as depicted' as closed and linear. 'Only later … do they discover that their universe is a sea of non-linearity…', Peter Cochrane, 'Virtual Mathematics', *The Mathematical Gazette*, vol. 80, no. 488, 1996, p. 267.

[47] ibid., p. 88.

[48] ibid., p. 90. M.D. King, 'Reason, Tradition and the Progressiveness of Science' in Gary Gutting, ed., *Paradigms and Revolutions: Appraisals and Applications of Thomas Kuhn's Philosophy of Science*, University of Notre Dame Press, Notre Dame, pp. 97-8, 106-7.

[49] Andrew Lugg, ''The Priority of Paradigms' Revisited', *Journal for General Philosophy of Science*, vol. 18, no. 1-2, 1987, p. 176.

> constituting a self authenticating tradition of thought. Rules for doing science are not therefore absolutes, they are relative to a particular viewpoint. This means that when scientists are faced with a choice between alternative articulations of the same fundamental perspective, they have common standards to guide them; but if they are forced to choose between alternative incommensurable world views, there are no over-arching criteria to which they can appeal. So scientific choices are only rational within the context of a single viewpoint of unquestioned authority; choice between alternative viewpoints, though constrained by logic and observation, necessarily involves "an element of arbitrariness," it is the last resort a non-rational social act, an act of faith likened by Kuhn to religious conversion.[50]

This perspective led Kuhn to exclaim that when '[e]xamining the record of past research from the vantage-point of contemporary historiography, the historian of science may be tempted to exclaim that when paradigms change, the world changes with them.'[51] In accepting that '[c]ultural and socio-economic factors' have an essential input into 'the establishment of new areas of scientific investigation',[52] it is worth noting that Erwin Schrödinger, the Nobel Prize winning physicist and close friend to Albert Einstein, evoked a similar position well before Kuhn:

> there is a tendency to forget that all science is bound up with human culture in general, and that scientific findings, even those which at the moment appear the most advanced and esoteric and difficult to grasp, are meaningless outside their cultural context. A theoretical science, unaware that those of its constructs considered relevant and momentous are destined eventually to be framed in concepts and words that have a grip on the educated community and become part and parcel of the general world picture - a theoretical science, I say, where this is forgotten, and where the initiated continue musing to each other in terms that are, at best, understood by a small group of close fellow travellers, will necessarily be cut off from the rest of cultural mankind[53]

---

[50] King, 'Reason, Tradition and the Progressiveness of Science', p. 105.
[51] Kuhn, *Structure of Scientific Revolutions*, p. 110.
[52] Lugg, 'Kuhn and the Philosophy of Science', p. 291.
[53] E. Schrödinger, 'Are There Quantum Jumps? Part I', *The British Journal for the Philosophy of Science*, vol. 3, no. 10, 1952, pp. 109-10. See also Prigogine and Stengers, *Order Out of Chaos*, p. 18. Prigogine notes

Schrödinger's thoughts on the relationship between culture and science lends support to the Kuhnian revelation that any decision to pursue or adhere to a particular paradigm can only be faith-based,[54] and, in Kuhn's words, transferring an 'allegiance from paradigm to paradigm is a *conversion* experience that cannot be forced' [emphasis added].[55] Kuhn's use of the word conversion is what King drew upon when he referred to the near-religiosity of paradigm-adherence. With an element of drama, Kuhn argued that when such an intellectual upheaval, where a scientific worldview is overturned, a 'revolution' is said to have taken place and, vitally, it is these major shifts that are argued to reinvigorate the 'scientific imagination'.[56] This re-imagination is what many scholars who have pursued the non-linear path seek within their respective fields. For the complexity theorist, the reductionism of the Newtonian world (one that is idealised through mathematics) presents as both a-historical and a-contextual.[57] Kuhn, of course, represents an historicist view of science, whereby theories are not only non-cumulative but the 'scientific rationality' that is used to evaluate theories is not fixed permanently and has 'altered significantly through the course of science'.[58] Kuhn's major contribution was that of establishing an alternative view to the customary histories of science as a linear progression; in a revolutionary manner, he argues that science does not progress cumulatively. In achieving this he provided a metaphor

---

in a later text, that the dominance of Newtonian thought is such that 'Schrödinger's equation is once again deterministic and reversible'. Prigigone, *The End of Certainty*, p. 12.

[54] See Kuhn, *Structure of Scientific Revolutions*, pp. 151, 158.

[55] ibid., p. 6. He also likens it to a 'Gestalt switch', Steven E. Phelan, 'What is Complexity Science, Really?', *Emergence*, vol. 3, no. 1, 2001, p. 125. Also see Kuhn, *Structure of Scientific Revolutions*, pp. 96-100.

[56] ibid. p. 6. The accusation that paradigms would be determined by 'mob rule' is a common accusation levelled at Kuhn (and also Habermas), most notably by Imre Lakatos. Yet as King points out, scientist, as a cohort, having such a 'conversation' could be better analogised as being 'more akin to a body of lawyers than to a revolutionary mob'. King, 'Reason, Tradition and the Progressiveness of Science', pp. 112-113. King portrays the scientist of Kuhn's world as 'constitutionalist', who would seek reform over revolution. ibid. Further, he feels that Kuhn fails in creating a sociological theory of science but he does effectively show how the authority structures that uphold them [paradigms], are modified, disrupted, and perhaps overthrown in the face of changes in scientific thought and technique' ibid. pp. 114-5.

[57] Mary Jo Hatch and Haridimo Tsoukas, 'Complex Thinking About Organizational Complexity: The Appeal of a Narrative Approach to Complexity Theory', Warwick Business School Research Bureau, Research Paper no. 251, 1997, p. 13.

[58] Phelan 'What is Complexity Science, Really?', p. 124.

of richness and depth that transcended its original bounds.[59] Epistemologically, natural science thereby presents as a 'paradigm of knowledge', heralding the significance of its historical and meta-theoretical development.[60]

The final point to mention, and very much a cornerstone of Kuhn's thesis, is that of incommensurability. The notion of the incommensurability of scientific theories connects with the non-cumulative aspect of knowledge and that between competing paradigms there exists 'no clear and incontrovertible basis upon which to make a rational choice between them'.[61] As Kuhn states:

> [the arrival of a] new paradigm often necessitates a redefinition of the corresponding science. Some old problems may be relegated to another science or declared entirely 'unscientific.' Others that were previously non-existent or trivial may, with a new paradigm, become the very archetypes of significant scientific achievement. The normal-scientific tradition that emerges from a scientific revolution is not only incompatible but often actually incommensurable with that which has gone before.[62]

Consequently, adherence to a particular paradigm means that at a foundational level there is no capacity to conduct a dialogue, as any discussion or desire to build knowledge collectively cannot reconcile the differing roots that define the very essence of their particular worldview (although in practical terms conversations can take place). The important issue is that a paradigm shift occurs at the *meta-theoretical* level (remembering that paradigms are the domain of the 'mature'[63] and 'normal' sciences), and it is that shift that has allowed the push of non-linear theories upon the boundaries of knowledge. Ilya Prigogine and Isabelle

[59] Phillip Stambovsky, 'Metaphor and Historical Understanding', *History and Theory*, vol. 27, no. 2, 1988, p. 127.
[60] Barnes, 'Thomas Kuhn', p. 85.
[61] ibid., p. 93. It is important to remember that '…new paradigms are born from old ones, they ordinarily incorporate much of the vocabulary and apparatus… that the traditional paradigm had previously employed. … Within the new paradigm, old terms, concepts, and experiments fall into new relationships one with the other', Kuhn, *Structure of Scientific Revolutions*, p. 149. Even Waltz acknowledges Kuhn position in relation to this, See Kenneth N. Waltz, *Theory of International Politics*, Addison-Wesley, Reading, 1979, p. 12.
[62] Kuhn, *Structure of Scientific Revolutions*, p. 103. For instance, the movement away from what are now predominately forgotten pre-Darwinian notions of biology (i.e. morphology) is representative of how a paradigm shift refocuses understanding and belief structures. See Kauffman, *The Origins of Order*, pp. 4-8.
[63] Kuhn, *Structure of Scientific Revolutions*, pp. 98-99.

Stengers directly invoked Kuhn when they argued the importance of chaos theory (discussed at length in the following chapter). Implicitly noting the issue of incommensurability, they explained the nature of a paradigm break:

> In Kuhn's view the transformation of a paradigm appears as a crisis: instead of remaining a silent, almost invisible rule, instead of remaining unspoken, the paradigm is actually questioned. Instead of working in unison, the members of the community begin to ask 'basic' questions and challenge the legitimacy of their methods. The group, which by training was homogonous, now diversifies. Different points of view, cultural experiences, and philosophical convictions are now expressed and often play a decisive role in the discovery of a new paradigm. The emergence of a new paradigm further increases the vehemence of the debate. The rival paradigms are put to the test until the academic world determines the victor. With the appearance of a new generation of scientists, silence and unanimity take over again. New textbooks are written, and once again things 'go without saying'[64]

In certain respects, incommensurability represents a stumbling block, but the notion of 'nested paradigms' rests easily with complexity theory and offers an alternative avenue for multiple dialogues without undermining a notion of truth and fact.[65] Moreover, it is vital to recognise that the social sciences are not, from the Kuhnian perspective, considered mature or normal.[66] Incommensurability, essentially, is a non-issue for *theories* in the social sciences – the impact is at the *meta-theoretical* level. What emerge are avenues for conversations to occur between those bodies of knowledge that have not constituted the paradigms via their research programmes, but whose presuppositions interpretively draw from them. Paradigms, in the social setting, become far more fluid in their possibilities.

This begins a softening of the notion of incommensurability and, to employ thoughts of rational hermeneutics, it is also possible to speak of Kuhn's paradigms

---

[64] Prigogine and Stengers, *Order Out of Chaos*, p. 308.

[65] Not least for getting that '"Theory," like the word "fact," is not, primarily, a scientific term, even though it does occur in the language of science. It is a metatheoretical concept for talking *about* science.' Gunnell, 'Realizing Theory', p. 926.

[66] Kuhn, *Structure of Scientific Revolutions*, passim, esp. chs. 1 and 2.

as 'traditions of interpretation', or his revolutions as 'discontinuities of meaning' in which different sciences that, despite being incompatible in a formal sense, reside alongside each other.[67] Strengthening the concept is Stephen Toulmin, who tempers the unease associated with paradigm shifts through an analogy with evolutionary biology. In effect, he suggests that an essential structure, held in matrices, allows for continuity 'between paradigmatic conceptual shifts'.[68] Such matrices can be easily equated to surrounding spheres of influences. Similarly notions of emergence and self-organisation sit comfortably with the idea that a structure can undergo substantial change but can still be considered to be the same structure.[69]

The idea of nested paradigms mitigates Kuhn's incommensurability argument (and his argument relating to maturity of science and his own privileging of science). The use of the Kuhnian notion of paradigms serves to illustrate the dominance of the Newtonian worldview and, in particular, the influence it has upon imagination. Obviously not all thinkers fall into this Newtonian category, but the manner in which the world is analogised often does (here reflecting the mature/immature Kuhnian line). Thus, Newton, or the Newtonian paradigm, in this context becomes more than just the embodiment of the laws of motion laid out

---

[67] Heelan and Schulkin 'Hermeneutical Philosophy and Pragmatism', p. 278.

[68] Gunnell, 'Realizing Theory', p. 928. Because of accusation of vagueness in reference to the use of the term 'paradigm', which he used to step away from 'theory', Kuhn himself suggested in his postscript of his second edition that perhaps the term 'disciplinary matrix' would serve best: ''disciplinary' because it refers to the common possession of the practitioners of a particular discipline; 'matrix' because it is composed of ordered elements of various sorts, each requiring further specification', Thomas Kuhn, *Structure of Scientific Revolutions*, 2nd ed., (International Encyclopaedia of Unified Science, vol. 2, no. 2), University of Chicago Press, Chicago, 1970, p.182. Indeed, a common accusation when using Kuhn is that he is not always clear where a theory starts and ends.

[69] How this might play out in the realm of IR, take Rosenau's example of NATO as an institution that has reorganised and adapted to changes that occurred from the environment, both internally and externally, as it has transformed from a Cold War deterrent to Soviet aggression to that of a regional peace enforcer. Rosenau, 'Many Damn Things Simultaneously', p. 85. It is also worth remembering, as Stephen Walt points, out that 'the debate over NATO expansion looks different depending on which theory one employs. From a "realist" perspective, NATO expansion is an effort to extend Western influence – well beyond the traditional sphere of U.S. vital interest- during a period of Russian weakness and is likely to provoke a harsh response from Moscow. From a liberal perspective, however, expansion will reinforce the nascent democracies of Central Europe and extend NATO's conflict-management mechanisms to a potentially turbulent region. A third view might stress the value of incorporating the Czech republic, Hungary, and Poland within the Western security community, whose members share a common identity that has made war largely unthinkable', Stephen M. Walt, 'International Relations: One World, Many Theories', *Foreign Policy*, no. 110, 1998, p. 30.

in the *Principia,* but is an idea that helps define (and contain) knowledge. Newtonianism became a creed that spread a mechanistic view of the world that did not necessarily have to marry with the actual reckonings of what Newton wrote.[70] Indeed, to draw an analogy from IR theory, it is the argument that:

> All individual thinkers transcend typology; and in social studies, generalizations are abstractions, mental conveniences, and to that extent unreal. They must be contrasted with the concrete, historical person in all his richness and possible inconsistency. It seems true that, when a proper name becomes used adjectivally of a school or way of thought, it falsifies the man possessing the name. Grotius was not a Grotian, nor Keynes a Keynesian; Freud was not a Freudian, nor Marx a Marxist, Machiavelli was not a Machiavellian ...[71]

The argument is hinged on amending the dominant outlook so that it may allow for the development of a foundation that accepts an external reality, but does not resort to the reductionism that atomises the interrelationships between agents or structures. Relating it directly to IR theory, such an assertion would not have to necessarily step away from elements of scientific realism, it would need only to re-cast and re-imagine the possibilities that lie beyond the rationalist zeal to reduce. This directly tackles the reductionist belief (implicitly and explicitly) that it can uncover universal laws, order and predictability. Instead, it is hoped that by accepting lessons from non-linear science, in particular complexity theory, that one can 'unconceal' an understanding of the world that does not reduce to a simplistic ontology but neither does it slip into unhelpful relativism. However, the pieces of this puzzle lie not only in the ruminations of the 'new' sciences that came to prominence in the late 20th century, but also in the way the pieces can be

[70] Yahuda Elkana, 'Newtonianism in the Eighteenth Century', *The British Journal for the Philosophy of Science*, vol. 22, no. 3, 1971, p. 299.

[71] Martin Wight, *Four Seminal Thinkers in International Theory: Machiavelli, Grotius, Kant, Mazzini,* eds Gabrielle Wight and Brian Porter, Oxford University Press, Oxford, 2005, p. 3. Further, Newtonian was 'applied to everything that dealt with a system of laws, with equilibrium, or even to all situations in which natural order on one side and moral, social and political order on the other could be expressed in terms of all embracing harmony', Prigogine and Stengers, *Order Out of Chaos*, p. 29. On Newton's impact as a metaphysicians and the impact of his followers in cultivating a philosophy of Newtonianism see Thomas Ahnert, 'Newtonianism in Early Enlightenment Germany, c. 1720 to 1750: Metaphysics and the Critique of Dogmatic Philosophy', *Studies in History and Philosophy of Science*, vol. 35, no. 3, 2004, pp. 471-91.

unearthed from within the Scientific Revolution and Enlightenment. The building of the positivist and reductionist position that defines the rationalist understanding of international relations emerged from a Europe that was challenging mystical and theological constraints.[72] Rebuilding the way we relate to science, to social science, and to IR theory also flows from the same root. In this respect, Newton was a giant amongst men.

Newton's World

In a letter to Robert Hooke, who coined the term 'cell' as the basic unit of biological life,[73] Sir Isaac Newton, the leviathan of the Scientific Revolution, wrote that 'If I have seen further it is by standing on ye shoulders of Giants'.[74] This sentiment replicated a similar view held by René Descartes, that of the linear progression of knowledge and of the creation of a mechanical representation of the world. The notion of a clockwork universe emerged under the tutelage and general influence of Newton and Descartes. Indeed, clocks, being 'the most common mechanical things in existence' during the seventeenth century, encouraged the closed mechanical outlook and became a defining analogy.[75] Timekeeping, the predictable movement of cogs, the universalism between timepieces, and the ability to understand the mechanics of the clock by examining, separately, its pieces advanced the possibility of ironclad laws within the natural sciences (and the hand of God could continue to be viewed as necessary to wind-

[72] It is worth noting in respect to the delineation and relationship between the 'Scientific Revolution' and the 'Enlightenment that retrospectively 'the scientific accomplishments of Bacon, Descartes, Newton and Locke were to be understood as having contributed to the liberation of the human spirit from the forces of superstition and religious dogmatism. Natural philosophers of the previous generation were thus retrospectively enlisted in the cause of Enlightenment, and the elevation of the significance of their accomplishments was accompanied by a corresponding diminution of the status of medieval achievements.' Harrison, 'Was there a Scientific Revolution?', p. 450.

[73] Newton and Hooke corresponded frequently but there existed a great enmity between them. Hooke felt that he was never properly recognised by Newton for his work on planetary motion prior to the publication of the *Principia*. John E. Moore, 'Review Article: "*A More Beautiful City": Robert Hooke and the Rebuilding of London After the Great Fire*' by Michael Cooper, *Institute of Historical Research*, March 2005, http://www.history.ac.uk/reviews/paper/moore.html, (accessed 12/08/2007). Even prior to this disagreement, tension had similarly arisen in relation to the nature of light. See Alan E. Shapiro, 'Twenty-Nine Years in the Making: Newton's Opticks', *Perspectives on Science*, vol. 16, no. 4, 2008, pp. 419-20.

[74] Moore, 'Review Article: *"A More Beautiful City"*'. Koyré notes that these words were not of Newton's own making and he was in fact drawing on but 'originates in the middle-ages', Koyré, *Newtonian Studies*, p. 11.

[75] Rogers, 'Descartes and the Method of English Science', p. 255.

on the clock and to make the occasional minor adjustments). The powerful analogy, which was assembled in part upon the inductive lawmaking of Newton, provided the axiomatic base from which reductionism allowed the creation of a paradigm of science, and thereby knowledge and certainty that continued even past the dominance of Newtonian science. In the preface to the first edition of his *Principia*, Newton outlines this mechanical vision:

> Since the ancients (as we are told by Pappas), made great account of the science of mechanics in the investigation of natural things; and the moderns, lying aside substantial forms and occult qualities, have endeavoured to subject the phænomena of nature to the laws of mathematics, I have in this treatise cultivated mathematics so far as it regards philosophy. The ancients considered mechanics in a twofold respect; as rational, which proceeds accurately by demonstration; and practical. To practical mechanics all the manual arts belong, from which mechanics took its name. But as artificers do not work with perfect accuracy, it comes to pass that mechanics is so distinguished from geometry, that what is perfectly accurate is called geometrical; what is less so, is called mechanical. But the errors are not in the art, but in the artificers. He that works with less accuracy is an imperfect mechanic; and if any could work with perfect accuracy, he would be the most perfect mechanic of all; for the description of right lines and circles, upon which geometry is founded, belongs to mechanics. Geometry does not teach us to draw these lines, but requires them to be drawn; for it requires that the learner should first be taught to describe these accurately, before he enters upon geometry; then it shows how by these operations problems may be solved. To describe right lines and circles are problems, but not geometrical problems. The solution of these problems is required from mechanics; and by geometry the use of them, when so solved, is shown; and it is the glory of geometry that from those few principles, brought from without, it is able to produce so many things. Therefore geometry is founded in mechanical practice, and is nothing but that part of universal mechanics which accurately proposes and demonstrates the art of measuring.[76]

A geometric understanding of the world of 'right lines' and circles was quite literally glorified by Newton as his text revealed the hidden mechanics and the

[76] Newton. *Principia,* Preface, p. XVII.

invisible powers of gravitational pull of not just the world, but of the universe. From the basic premises that he laid down, a scientific methodology that has permitted much of what has been, and continues to be, induced on the foundations of relatively few principles that are essentially additive in nature.[77] The perceived solvability of the world began to emerge from Newton's *Principia,* and with this success the idea of certainty in understanding the natural world become firmly established.[78] Rooted in this idea is the linearity of what is knowable about the natural world. At length and in support of this, Newton continues:

> But since the manual arts are chiefly conversant in the moving of bodies, it comes to pass that geometry is commonly referred to their magnitudes, and mechanics to their motion. In this sense rational mechanics will be the science of motions resulting from any forces whatsoever, and of the forces required to produce any motions, accurately proposed and demonstrated. This part of mechanics was cultivated by the ancients in the five powers which relate to manual arts, who considered gravity (it not being a manual power), no otherwise than as it moved weights by those powers. Our design not respecting arts, but philosophy, and our subject not manual but natural powers, we consider chiefly those things which relate to gravity, levity, elastic force, the resistance of fluids, and the like forces, whether attractive or impulsive; and therefore we offer this work as the mathematical principles of philosophy; for all the difficulty of philosophy seems to consist in this – from the phænomena of motions to investigate the forces of nature, and then from these forces to demonstrate the other phænomena[79]

Offered by Newton, and accepted by the scientific community, was the certainty of the 'mathematical principles of philosophy' from which, via their correct application and understanding of these 'forces', other phenomena could be readily

[77] For example, in respect to the study of international relations, see Emilian Kavalski, 'The Complexity of Global Security Governance: An Analytical Overview', *Global Society*, vol. 22, no. 4, 2008, p. 430-1.
[78] From Book One of the *Principia* 'Of The Motion of Bodies' take the following: 'And if that body is continually disturbed by the action of some foreign force, we may nearly know its course, by collecting the changes which that force introduces in some points, and estimating the continual changes it will undergo in the intermediate places, from the analogy that appears in the progress of the series.', Newton. *Principia,* Book I, Part III, p. 67.
[79] ibid., Preface, pp. XVII-XVIII

derived. Hence, not only linearity (which is evident in the 'rational mechanics') but also reductionism became entrenched as a law of the universe. Further to this, a universe in this vision (that is, the single-verse or story that encompasses all that is around) speaks of universalism. At this focal point Newton revealed a desire when he wrote that:

> I wish we could derive the rest of the phænomena of nature by the same kind of reasoning from mechanical principles; for I am induced by many reasons to suspect that they may all depend upon certain forces by which the particles of bodies, by some causes hitherto unknown, are either mutually impelled towards each other, and cohere in regular figures, or are repelled and recede from each other; which forces being unknown, philosophers have hitherto attempted the search of nature in vain; but I hope the principles here laid down will afford some light either to this or some truer method of philosophy.[80]

Newton felt from his laws that an inductive scientific methodology (relying on the already mentioned inherent universalism, linearity and reductionism), representing the shift from both Aristotelian syllogistic logic[81] and Cartesian deductive tendencies,[82] would unveil higher scientific truths. It is not the intention of this study to extrapolate the actual reckonings and underlying logic of Newton's *Principia* in any detail. It is, however, its intention to examine his definitions, his laws and, from that, his rules, that which has become synonymous with the dominant paradigm. Of his definitions, the second is significant: 'The quantity of motion is the measure of the same, arising from the velocity and quantity of matter conjunctly'. He expands on this by adding: 'The motion of the whole is the sum of the motions of all the parts; and therefore in a body double in

---

[80] ibid., Preface, p. XVIII

[81] Aristotle's syllogisms were inductive in nature but the induction relies upon 'shared assumptions', Stephen Gaukroger, 'Descartes: Methodology', in George Henry Radcliffe Parkinson, ed., *The Routledge History of Philosophy, Vol 4: The Renaissance and Seventeenth-Century Rationalism*, Routledge, London, 1993, p. 173. This acknowledges that 'Aristotle's view of science was that it is an inductive-cum-deductive method in which we proceed from observation to general principles and back again to observation.' Philip O. Sijuwade, 'Recent Trends in the Philosophy of Science: Lessons for Sociology', *Journal of Social Sciences*, vol. 14, no. 1, 2007, p. 56.

[82] On the decline of Aristotelian physics and its replacement by Descartes see L.W.B. Brockliss, 'Aristotle, Descartes and the New Science: Natural philosophy at the University of Paris, 1600-1740', *Annals of Science*, vol. 38, no. 1, 1981 , pp. 33-69.

quantity, with equal velocity, the motion is double; with twice the velocity, it is quadruple.'[83] The additive nature of his clean and quite brilliant theory emerges and from this definitional base also come his axioms, his three laws, from which the linearity and the closed nature of his world became evident.[84] The laws, as Newton put them in all their simplicity, are:

LAW I:	Every body perseveres in its state of rest, or of uniform motion in a right line, unless it is compelled to change that state by forces impressed thereon.
LAW II:	The alteration of motion is ever proportional to the motive force impressed; and is made in the direction of the right line in which that force is impressed.
LAW III:	To every action there is always opposed an equal reaction; or the mutual actions of two bodies upon each other are always equal, and directed to contrary parts.[85]

A large part of the attractiveness and persuasiveness of these general principles, that represent the lawful, deterministic and reversible nature of trajectories,[86] is that this new worldview provided converts with an inductive methodology that provided solutions to a multiplicity of phenomena (without being hamstrung by the assumptions that ruled deductive methods). Yet, and more so than the methodological implications themselves, it was the ontological and epistemological ramifications that would impact thinking and imagination beyond what might be considered the traditional bounds of science. In the latter part of the *Principia*, Newton reveals his four 'Rules of Reasoning in Philosophy' (and by this he explicitly refers to experimental philosophy – that is, science) that would underscore what was to embody what it meant to be Newtonian. They are:

---

[83] Newton, *Principia,* p. 1

[84] The concept of closed and open systems are discussed in chapters two and three.

[85] ibid., p. 13. In short, 'the triumph of Newtonian Science is the discovery that a single force, gravity, determines both the motions of planets and comets in the sky and the motion of bodies falling towards the earth. Whatever pair of material bodies is considered, the Newtonian system implies that they are linked by the same force of attraction. Newtonian dynamics thus appears to be doubly universal. The definition of the law of gravity that describes how masses tend to approach one another contain no reference to any scale of phenomena. It can be applied equally well to the motion of atoms, of planets, or of the stars in the galaxy.' Prigogine and Stengers, *Order Out of Chaos*, p. 59.

[86] Prigogine and Stengers, *Order Out of Chaos*, p. 60. This will be expanded upon in the next chapter.

RULE I: We are to admit no more causes of natural things than such as are both true and sufficient to explain their appearances.

To this purpose the philosophers say that Nature does nothing in vain, and more is in vain when less will serve; for Nature is pleased with simplicity, and affects not the pomp of superfluous causes.

RULE II: Therefore to the same natural effects we must, as far as possible, assign the same causes.

As to respiration in a man and in a beast; the descent of stones in Europe and in America; the light of our culinary fire and of the sun; the reflection of light in the earth, and in the planets.

RULE III: The qualities of bodies, which admit neither intension nor remission of degrees, and which are found to belong to all bodies within the reach of our experiments, are to be esteemed the universal qualities of all bodies whatsoever.[87]

RULE IV: In experimental philosophy we are to look upon propositions collected by general induction from phænomena as accurately or very nearly true, notwithstanding any contrary hypotheses that may be imagined, till such time as other phænomena occur, by which they may either be made more accurate, or liable to exceptions.

This rule we must follow, that the argument of induction may not be evaded by hypotheses.[88]

---

[87] And it continues its universalistic bent: 'For since the qualities of bodies are only known to us by experiments, we are to hold for universal all such as universally agree with experiments; and such as are not liable to diminution can never be quite taken away. We are certainly not to relinquish the evidence of experiments for the sake of dreams and vain fictions of our own devising; nor are we to recede from the analogy of Nature, which uses to be simple, and always consonant to itself. We no other way know the extension of bodies than by our senses, nor do these reach it in all bodies; but because we perceive extension in all that are sensible, therefore we ascribe it universally to all others also. That abundance of bodies are hard, we learn by experience; and because the hardness of the whole arises from the hardness of the parts…'. Newton, *Principia,* Book 3, pp. 398-9.

[88] ibid., Book 3, pp. 398-400. Interestingly in the first and very rare first edition of the *Principia* the 'Rules' are referred to as hypotheses. See Koyré, *Newtonian Studies*, p. 30.

His rules of reasoning are tightly written. Rule one puts forward the importance of empirical data,[89] but what also surfaces is the reductionism within his system, as 'no more causes' than that which is 'sufficient to explain' is to become synonymous with a 'Newtonian perspective'. Rule two follows logically from the first,[90] but for those critiquing the Newtonian perspective, it is here that the notion of linear cause and effect materialises. Rule three elicits little disagreement, displaying the universalism that also so defines the Newtonian world. Rule four is formative, as it speaks of hypotheses and induction[91] – Newton may well do away with hypotheses (in itself assisting paradigm defence) but the undercurrent for his fourth rule is certainty and predictability (and anything that doesn't fit to become an exception). Newton had shone a light onto the world, from this light the scientific revolution became defined, yet the impact of Newton and Newtonian science extended far beyond the explanations of gravity and motion.[92] He himself was to become the embodiment of the paradigm, and his ideas transcended not only into the scientific but also into the popular imagination.

From such a perspective Newton can be understood to represent a pinnacle of scientific endeavour; one of the fathers of the Enlightenment, a figure whose influence supposedly tore away at the shrouds of mysticism and superstition. He continues to fascinate and holds in the eyes of one scholar a 'unique magistral

[89] Quayshawn Spencer, 'Do Newton's Rules of Reasoning Guarantee Truth … Must They?', *Studies in History and Philosophy of Science*, vol. 35, no. 4, 2004, p. 760-1. Moreover, as Kuhn states, 'empirical work' is always 'undertaken to articulate the paradigm theory', Kuhn, *Structure of Scientific Revolutions*', p. 29.

[90] ibid., p. 761.

[91] 'First, it instructs us that theories deduced from phenomena and generalized by induction always override theories that fail to do so', this represents the significant split from Cartesian deduction. Secondly the rule 'instructs us to model the world as idealizations. Third, the clause after the last comma suggests that natural philosophy is an ongoing program of making ever better idealizations of the world. The latter two points turn natural philosophy into an exact science, not insofar as it calls for idealizations, but insofar as it suggests that phenomenal deviations from those idealizations, or theory dependent second-order phenomena…' ibid. It is also worth acknowledging that today physical experimentation are 'rarely described in a language that permits deductive exploration', Holland, *Hidden Order*, p. 161.

[92] The sentiment is capture well by Ernan McMullin: 'The impact of his *Philosophiae naturalis principia rnathematica* on the imaginations of philosophers and physicists, now for the first time separating into two different professions, was so great that it was altogether natural that the work should rapidly become the paradigm of what natural science should look like. And his scattered remarks on method in the pages of the *Principia* and the *Opticks* took on a corresponding authority, even though it was not at all easy to weave from them a consistent philosophy of science.' Ernan McMullin, 'The Impact of Newton's Principia on the Philosophy of Science', *Philosophy of Science*, vol. 68, no. 3, 2001, pp. 279-280.

position … in the formation of modern exact science'.[93] His work, represented by his laws, his generalizations, of motion,[94] cemented the way in which the world was thought to function, not only physically, but also in a social context. Newton became the embodiment of modern science, and his contemporaries, even his critics, knew well that they lived in the shadow of his achievements.[95] As Alexander Pope's epitaph reads at the beginning of the chapter, it was Newton who lay forth the hidden laws of nature, and, with religious overtones, brought light from the darkness that preceded the Enlightenment.[96] It was the transcendence of Newton's work beyond the ivory towers of the universities, and its transfer to the popular imagination that is one of the most telling elements that accounts for the development of the Newtonian paradigm. In time not long past his death, Voltaire wrote that Newton was seen 'as the *Hercules* of fabulous Story, to whom the Ignorant ascrib'd all the Feats of ancient Hereos'.[97] Nature and the world had been brought into the fold of what men could understand and control:

> Common men associated the new philosophy with the name of Newton because it appeared that Newton, more than any other man, had banished mystery from the world by discovering a 'universal law of nature,' thus demonstrating, what others had only asserted, that the universe was rational and intelligible through and through, and capable, therefore of being subdued to the uses of men.[98]

---

[93] I. Bernard Cohen, 'Newton in the Light of Recent Scholarship', *Isis*, vol. 51, no. 4, 1960, p. 489.
[94] Its important to remember that he did not 'discover' the laws of motion, that honour falls to Descartes and Galileo, he was the first to formulate them by developing 'the clear understanding of the method and meaning of scientific enquiry; that it was his invention of calculus that enabled him to demonstrate the identity of terrestrial and celestial gravitation and to find out the fundamental law of attraction that binds – or at least until recently bound – together the smallest and largest bodies – stars and atoms – of the infinite Universe. We know too, of course, that it is not to him, but to his great rival Leibniz, the we owe *de facto* the actual spread and development of the infinitesimal calculus, without which the gradual extension and perfection of the Newtonian *systema mundi* would be impossible', Koyré, *Newtonian Studies*, pp. 3-4.
[95] A. Rupert Hall, *From Galileo to Newton, 1630-1720: The Rise of Modern Science 2*, Fontana Collins, 1963, p. 312. It is put with 'the possible exception of Leibniz'. ibid.
[96] Pope, 'Epitaph intended for Sir Isaac Newton' in Stempel, 'Angels of Reason', p. 64.
[97] Voltaire, 'Letter XIV on Des Cartes and Sir Isaac Newton' in *Letters Concerning the English Nation*, Peter Davies, London, 1926, p. 90.
[98] Carl L. Becker, *The Heavenly City of the Eighteenth Century Philosophers*, Yale University Press, New Haven, 1932, p. 60.

The Newtonian world was coming into its own. Newton's work didn't just seep into the scientific imagination, the imagination had become bound by what it presented as truth, indeed, he emerged as the 'symbol of the power of the human mind'.[99] He had become in the mind of many the 'sole authoritative spokesman on scientific thought'.[100] In short, he was portrayed as the 'greatest mind ever to enter the kingdom of science'.[101] Popularly, in verse from the period, to doubt Newton was to infer that one questioned God's truth,[102] indicating how quickly a paradigm, once established, enters, becomes a part of, and helps define, a culture. Of the reaction of the English to his death, Voltaire noted that 'His Countrymen honour'd him in his Life-Time, and interr'd him as tho' he had been a King who had made his People happy.'[103] The importance of Newton as a revolutionary figure is defined even in his death, being entombed with great pomp and ceremony at Westminster Abbey. The inscription upon his tomb, which has again been popularised in more recent times,[104] reads:

> Here is buried Isaac Newton, Knight, who by a strength of mind almost divine, and mathematical principles peculiarly his own, explored the course and figures of the planets, the paths of comets, the tides of the sea, the dissimilarities in rays of light, and, what no other scholar has previously imagined, the properties of the colours thus produced. Diligent, sagacious and faithful, in his expositions of nature, antiquity and the holy Scriptures, he vindicated by his philosophy the majesty of God mighty and good, and expressed the simplicity of the Gospel in his manners. Mortals rejoice that there has existed such and so great an ornament of the human race! He was born on 25th December, 1642, and died on 20th March 1726/7.[105]

---

[99] Julia L. Epstein, 'Voltaire's Myth of Newton', *Pacific Coast Philology*, vol. 14, 1979, p. 27.

[100] Hall, *From Galileo to Newton*, p. 312.

[101] Cohen, 'Newton in the Light of Recent Scholarship', p. 491.

[102] To quote the verse: 'And, so you think that Newton told a lie; Where do you hope to go when you die?', ibid., p. 492.

[103] Voltaire, 'Des Cartes and Sir Isaac Newton', p. 86.

[104] This time by a work of (dreadful but well-paced) fiction that relies on the very mix of science, religion and morality that is indicative of a (non-reflexive) prevailing paradigm. See Brown, Dan, *The Da Vinci Code*, Bantam, London, 2003.

[105] 'Sir Isaac Newton', *Westminster Abbey: From 1605 to Today*, http://www.westminster-abbey.org/history-research/monuments-gravestones/people/12186, accessed 14/06/2007, The inscription was translated 'from G.L. Smyth, The Monuments and Genii of St. Paul's Cathedral, and of Westminster Abbey (1826), ii, 703-4.'

The connection between religion, science and morality has been played out on many occasions. In the case of Newton the intensity of the connections was immense; however, the issue of consequence is how the scale of social transference underwrites the concept of a paradigm being of greater or lesser cultural significance. His nineteenth century biographer, in far from muted tones, referred to Newton as the 'high priest of science'; he was an individual Christians could admire for his work beyond his more widely acknowledged intellectual pursuits.[106] Reading between the lines, this is a nod to the man who was considered to be the leader of the so-called 'scientific revolution' and spent a great deal of his 'time and energy using his mathematical, physical, and celestial theories to uncover patterns of Biblical revelation'.[107] To some degree this ties into Newton's worldview, as he was not averse to allowing God to rectify inconsistencies in his theories, hinting that irregularities in his systems were possibly smoothed over by the Creator on the odd occasion.[108]

Curiously, this can be contrasted with William Blake's criticism of Newton. Blake ran against the popularity and accolades of Newton's science.[109] Newton, in Blake's graphic image below, is a young muscular man, reminiscent of the neo-Hellenic statues of the Renaissance. Leaning forward upon a lichen-covered rock, in a cave (could it be Plato's?), he himself appears as a natural organic being seemingly coming forth, almost being birthed, from the cavern walls. But within this image, Newton is focussed not on the natural world around, of which Blake depicts him as intrinsically a part of. Rather his mind is fixed on his task of mapping and abstracting the world around with his Euclidean instruments of science, understanding the natural world is derived via mathematical

[106] David Brewster quoted in Cohen, 'Newton in the Light of Recent Scholarship', p. 491.
[107] Jack A. Goldstone, 'Efflorescences and Economic Growth in World History: Rethinking the "Rise of the West" and the Industrial Revolution', *Journal of World History*, Fall 2002 vol. 13 no. 2, p. 372. Newton's forays into the realm of alchemy are also extensively documented. See: Michael White, Isaac *Newton: the last sorcerer*, Fourth Estate, London, 1997; John T. Young, 'Isaac Newton's Alchemical Notes in the Royal Society', *Notes and Records of the Royal Society*, vol. 60, no. 1, 2006, pp. 25-34.
[108] Stephen Toulmin, 'The Idol of Stability', The Tanner Lectures on Human Values, delivered at the University of Southern California, February, 1998, p. 332.
[109] This point is well established, for example, Cohen briefly notes Blake's displeasure; Cohen, 'Newton in the Light of Recent Scholarship', p. 492.

measurement, abstraction and reduction. From this 'Newtonian space', Blake recognised the theological underpinnings: faith, blended with an emerging conception of scientific certainty (and those who followed), were 'bred by the metaphysics of the scientific Angel who, like all scientists, never alters his opinion'.[110]

NOTE:
This figure is included on page 58 of the print copy of the thesis held in the University of Adelaide Library.

Figure 1: William Blake's *Newton,* 1795/circa 1805.[111]

[110] Blake quoted in Stempel, 'Angels of Reason', p. 73. Similarly, Blake was not fond of either generalisations or the mathematisation of knowledge. On generalisation he pressed that 'To Generalize is to be an Idiot. To Particularize is the Alone Distinction of Merit. General Knowledges are those Knowledges that Idiots possess.' On Mathematics he is emphatic: 'God forbid that Truth be confined to Mathematical Demonstration!' William Blake, *Annotations to Sir Joshua Reynolds' Discourses*, (c. 1808)' in Lorenz Eitner, *Neoclassicism and Romanticism 1750-1850*, vol. 1 (sources and documents in the history of art series), Prentice-Hall International, London, 1971, pp. 121, 125. In discussing the depiction of science as a 'cancer in the body of culture' Noble laureate (for chemistry) Ilya Prigogine with Isabelle Stengers draw on a letter written by Blake to Thomas Butts (November 22, 1802) imploring that '…May God us keep / From single vision and Newton's sleep', Prigogine and Stengers, *Order and Chaos*, p. 30.

[111] William Blake, *Newton*, 1795/Circa 1805, Tate Collection, available at: http://www.tate.org.uk/servlet/ViewWork?cgroupid=999999961&workid=1122, accessed 17/05/06. The display caption reads that 'Isaac Newton was the scientist who first understood planetary motion. Blake was critical of such disciplined reasoning. Through the accidental nature of the colours and texture of the rock Blake asserted his belief in the supremacy of the creative imagination.' ibid.

Considering this perspective, Newton casts a different impression of the man who so helped put the Enlightenment on its rationalist path devoid of the superstition and darkness that came before. The Kuhnian conception of scientific paradigm as the embodiment of the prevailing cultural and sociological commitments of the period is captured insightfully by poet and artist. But more than anything else, it is the contradiction of the conjoined relationship with nature that Blake's Newton is seemingly blissfully unaware, whilst God, in Newton's world, is found only in cold and impersonal axioms that have underwritten his generalised laws.[112]

Enlightened Science

The tale of the Enlightenment and the search for certainty is not Newton's story alone. Indeed, in constructing a potted (though carefully considered) history of the development of the dominant scientific paradigm, other figures rise to prominence well before the publication of Newton's *Principia*. The foundations of the mechanistic worldview so closely associated with the Scientific Revolution were initially very much informed by the reductionist and axiomatic methods that stemmed from the thoughts of Descartes. The Age of Reason – 'the birth of the modern age' – can be said to begin with Descartes, the 'great tree of knowledge' and, again ironically, the near-religious way in which mathematics emerged as the purest means to understand the elementary particles of that all-encompassing tree.[113] For Descartes, reason was paramount and he pressed that 'we should never allow ourselves to be convinced by anything except by the evidence of our reason'.[114] Cartesian thought was and, in many respects, still remains (despite being pushed aside by Newton), the dominant manner in which scientific knowledge is explored. Effectively, the interrelationship between epistemology and methodology is still attuned to Cartesian approaches toward exploration (although now also bound by Popperian notions of falsification). It is this that has

[112] Indeed, it is possible to argue that social alienation can be said to have been spawned from the rationality of classical science. Prigogine and Stengers, *Order Out of Chaos*, p. 8.

[113] John Cottingham, 'Descartes' in *The Great Philosophers*, Ray Monk and Frederic Raphael, eds, Phoenix, London, 2004, pp. 95-97.

[114] René Descartes, *Discourse on Method and Related Writings*, trans., Desmond M. Clarke, Penguin, London, 1998, Part IV, p. 27.

evolved into what is now known today as the modern scientific method.[115] Descartes explained this in pointing out that 'each truth that I discovered became a rule, that would later serve to discover other truths'.[116] Isaiah Berlin artfully conveys a rudimentary understanding of Cartesian methodology when he states that:

> All true knowledge is by nature cumulative. If you have discovered something and established its truth by means which can be regarded as scientific, that is to say, as susceptible to proof, and therefore as insusceptible to refutation, or incapable of refutation, at any rate, then what is proved is proved, and upon that basis you can build further knowledge. If we can establish certain mathematical or geometrical propositions, perhaps certain propositions in physics or in astronomy, as being true, there is no need for our successors to go over this again. We can stand on the shoulders of our predecessors and build from there. There is no need even to know what our predecessors have done: if they have done their work well, we accept it as being true. We can check their methods. Science simply consists in using methods which any rational person can teach to any other rational person, and which any third rational person can check for himself. There cannot be any concealment, there is nothing private, there is nothing mysterious, there is nothing privileged here. This is how true knowledge advances; this is how science advances.[117]

This establishment of the dominance of 'deductive rationality over all other modes of thinking'[118] was furthered by the notion that the same 'underlying explanatory schema' bound all observable phenomena.[119] It is *this* element of

---

[115] This is certainly the case outside of academe in terms of what is popularly accepted to constitute knowledge. Further, this assertion accepts the fact that Newton's work trumped much of the scientific thought of Descartes (as discussed later).

[116] Descartes, *Discourse on Method*, Part II, p. 17.

[117] Isaiah Berlin, 'The Origins of Cultural History: 'Geisteswissenschaft' and the Natural Sciences Vico versus Descartes', Second of three Gauss lectures given at Princeton in 1973. Available online Isaiah Berlin Virtual Library, http://berlin.wolf.ox.ac.uk/lists/nachlass/origins2.pdf (accessed 25 March, 2006). To quote Descartes 'In short there is nothing in the whole of nature, nothing, that is, which should be referred to purely corporeal causes, i.e. those devoid of thought and mind, which is incapable of being on the basis of these self same principles.' From the *Principles of Philosophy* [1647] quoted in Cottingham, 'Descartes', p. 97.

[118] Marie Josephine Diamond, 'The Social Configuration of Descartes' Discourse on Method', *Dialectical Anthropology*, vol. 7, no. 1, 1982, p. 3.

[119] John Cottingham, 'Descartes', p. 96.

Cartesian thought that has not only survived but has incorporated itself as a basic tenet of 'traditional science' – reductionism. That is, Descartes:

> claimed that all natural phenomena, terrestrial or celestial, organic or inorganic, no matter how striking their surface differences, can be reduced to, or fully explained in terms of, the elementary mechanics of the particles out of which the relevant objects are made up[120]

Descartes simplified how knowledge should be approached with his belief in reductionism, yet this belief is what makes it difficult 'to account for the unity of complex entities'.[121] Reducing complex phenomena to simple elements has a homogenising effect,[122] although generalizing can assist by conveniently levelling the terrain that wishes to be understood. If it is put forth as a 'law', or as an absolute, the generalization runs the risk of becoming the 'reality'. Many scientists, including the social variants, have done and continue to make this mistake of committing the 'fallacy… of confusing the model with reality'.[123] It is here that the reductionist reality takes root, with the mathematising of nature and the insistence that matter has no attributes beyond those that are quantifiable.[124] For social theorists the movement of Cartesian thought from the natural to the social, where the epistemological value of social experience is rejected, is what is most telling.[125] Further to this, the transference of reductionist principles were unknowingly contributing to the establishment of some of the most well-traversed meta-theoretical battlefields of the future.

Berlin, with an eye to the past, certainly spoke of a coming divorce between the humanities and the natural sciences, (and suggested that this argument dated back

[120] ibid., p. 96.
[121] Emily Grosholz, *Cartesian Method and the Problem of Reduction*, Clarendon Press, Oxford, 1991, p. 2.
[122] ibid.
[123] Mathews, et al., 'Why Study the Complexity Sciences', p. 441.
[124] Emily Grosholz, 'Geometry, Time and Force in the Diagrams of Descartes, Galileo, Torricelli and Newton', *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association*, vol. 2: Symposia and Invited Papers, 1988, p. 238.
[125] Marie Josephine Diamond, 'The Social Configuration of Descartes' Discourse on Method', *Dialectical Anthropology*, vol. 7, no. 1, 1982, p. 2.

to the life of Giambattista Vico).[126] Moreover, it can be argued that proto-positivists like Descartes and Newton, and positivists like Comte, who sought a unified theory, a system that encompassed all the sciences, came to represent one of the fundamental aims of the Enlightenment project. It is this idea of science that has helped define 'the social, legal and technological organisation of our world', and, as Berlin wryly notes, it was certainly going to incite a reaction at some stage by those who felt that science and reason underwrites a singular and homogenous concept of the system that binds and constrains all within it.[127] But resistance to the Cartesian outlook began much earlier. The thoughts of the late seventeenth and early eighteenth century Italian philosopher Vico became increasingly critical of Cartesian rationalism and eventually totally rejected it. For Vico, a theory of such 'clear and distinct ideas'[128] ignored the involvement of people in creation of the social world. Consequently, the 'ontological status of the simplest nature' as decreed by a Cartesian outlook was simply untenable.[129] Indeed, his thoughts resonate strongly with those that stand in opposition to Cartesian influences (and, by extension, Newton) that Vico as a thinker is experiencing something of a renaissance. Moreover, he is increasingly represented as father figure of the counter-Enlightenment who, after being lost for a couple of centuries, has been enthusiastically 'rediscovered'.[130]

---

[126] Isaiah Berlin, *The Proper Study of Mankind: An Anthology of Essays*, Henry Hardy and Roger Hausheer, eds, 1997, pp. 326, 357.

[127] ibid., p. 328. Berlin's full 'list' (one assumes it is not exhaustive) 'From Descartes and Bacon and the followers of Galileo and Newton, from Voltaire and the Encyclopaedists to Saint-Simon and Comte and Buckle, and, in our own century, H. G. Wells and Bernal and Skinner and the Viennese positivists…' p. 328.

[128] Leon Pompa, *Vico: A Study of the 'New Science'*, Cambridge University Press, Cambridge, 1990, p. 75

[129] Leon Pompa,(ed. and trans.), 'Introduction', *Vico: Selected Writings*, Cambridge University Press, Cambridge, 1982, p. 6.

[130] See George de Santillana, 'Vico and Descartes', *Osiris*, vol. 9, 1950, pp. 565-80. Santillana also notes that Vico 'is and remains a transcendentalist' (ibid., 571) highlighting links to Kant (via Hume). Some suggest the father figure status is undeserved. In her review of Pompa's *Vico: a Study of the 'New Science'*, Cecilia Miller rejects the manner in which '[m]odern myths depict Vico as the leader of the Counter-Enlightenment, as the precursor of Hegel and Marx, as the father of social science, as a modern thinker trapped in the early modern age, and as an anti-Catholic', Cecilia Miller (review) 'Vico: a Study of the 'New Science'', *History and Theory*, vol. 34, no. 1, 1995, p. 132.

It is Vico's criticism of mathematics that attracts significant attention.[131] In his opinion, the manner in which adherents to the Cartesian method readily reduce concepts to manufactured rules, definitions and axioms that enable an individual to follow an argument to its logical conclusion, do so without consideration that '[m]athematics was not a discovery but a human invention'.[132] Moreover, the insightful criticism that he levels is that mathematics can be viewed as merely a game in which the understanding that is hoped to be drawn from its usage is essentially 'a play of abstractions controlled by their creators'.[133] Looking to the future, the consequences of Vicean thought upon modern game-theory, at its most prevalent in the American-dominated area of IR theory, is to some self-evident.[134] If the parameters are manipulated by those seeking to understand, then the knowledge garnered, even if interesting or revealing on occasions, its usefulness as a universal axiom, is undermined. This is further cemented when married to Kuhn's conception of paradigms, as the parameters in themselves reflect the dominant worldview and are hence contingent upon that bias. Of course, history shows that the actual development and proliferation of most academic fields continued unabated by such concerns. For Vico, in his own words, it is not only when the human mind 'is lost in ignorance [that] man makes himself the measure

[131] See William J. Mills, 'Positivism Reversed: The Relevance of Giambattista Vico', *Transactions of the Institute of British Geographers*, New Series, vol. 7, no. 1, 1982, pp. 1-14.
[132] Berlin, *The Proper Study of Mankind*, p. 341.
[133] ibid., See also Berlin 'Geisteswissenschaft and the Natural Sciences' pp. 17-18.
[134] From his Gramscian perspective Robert Cox notes that 'neorealist theory has extended itself into such areas as game theory, in which the notion of substance at the level of human nature is presented as a rationality assumed to be common to the competing actors who appraise the stakes at issues, the alternative strategies, and the respective payoffs in a similar manner. This idea of a common rationality reinforces the nonhistorical mode of thinking.' Cox then moves to acknowledge Vico's insights 'for whom the nature of man and of human institutions should not be thought of in terms of unchanging substance but rather as a continuing creation forms'. Robert W. Cox, *Approaches to World Order*, with Timothy J. Sinclair, Cambridge University Press, Cambridge, 1996, pp. 92-3. This point is pursued further in Chapter Five. This quote is also drawn from that same tract (reprinted here) that famously declared that 'Theory is always *for* someone and *for* some purpose' displaying an inherent historicism. ibid., p. 87. Couple this with Kuhn's dictum that '*The road from scientific law to scientific measurement can rarely be travelled in the reverse direction*' [author's emphasis] and their lies the risk that measuring in itself is bound in a cultural/human experience context. Kuhn, 'The Function of Measurement', pp. 189-90. Counter to this, it is important to highlight that some scholars feel that Cox overplayed his argument. Murielle Cozette has argued that Cox's certainty that '(neo) realists completely missed the point' in respect to critical self reflection was misguided. The father figure of classical realism, Hans Morgenthau, Cozette argues, 'forcefully advocated' that 'science is not value neutral'. Murielle Cozette, 'Reclaiming the Critical Dimensions of Realism: Hans J. Morgenthau on the Ethics on Scholarship', *Review of International Studies*, vol 34, no. 1, 2008, p. 24-5. Of course, Cox was directing his claim at neorealism not classical realism, however, Cozette's claim the Morgenthau is misrepresented misses the point as Morgenthau's scientific approach was still framed, indirectly, by the Newtonian paradigm. See Chapter Four.

of all things'[135] but truth (in the 'world of man' not nature) in itself should be viewed neither as static nor as a discovery but as dynamic and as a product.[136] To abstract the world in order to understand is a reasonable and necessary process. Yet many liberties are taken when reducing down (or up)[137] to atomised entities in order to comprehend complex processes. Astronomical mechanics is a good case in point in this regard, as it proved to be one of the greatest achievements of the Scientific Revolution and provided some of the most convincing arguments for a paradigm of scientific certainty. Yet, as Kuhn would suggest, such claims are always contingent.

Johannes Kepler's determination to 'make the shoe fit' in respect to proving the elliptical orbits of the planets provides an excellent example. His mathematical manipulation of the available data of the Martian orbit was a painstaking and ultimately fruitful experience that was later postulated as a scientific 'law'. Kepler's laws of planetary motion were generalisations that pertained to the motions of all planets within the solar system, a claim that was, at the time, not supported by research and observational data.[138] Cynically, it can be said that his theory passed the test for which it was constructed to pass.[139] Kuhn had strong opinions on the matter when he declared, in the postscript of his second edition, that:

---

[135] Giambattista Vico, *The New Science*, 3rd ed., eds and trans Thomas Goddard Bergen and Max Harold Fisch, Cornell University Press, Ithaca, 1968 [1744], p. 60, sec. II, para. 120. Vico takes this point further expressing that 'it is another property of the human mind that whenever men can inform no idea of distant and unknown things, they judge them by what is familiar and at hand', ibid p. 60. This as Whittaker notes predates 'Kant's doctrine that we *make* mathematical truth – in Vico's phrase, *verum* is *factum*', Thomas Whittaker, *Reason: A Philosophical Essay with Historical Illustrations*, Greenwood Press Publishers, Westport, 1968 [1934], p. 134.

[136] Benedetto Croce, *The Philosophy of Giambattista Vico*, Trans. R. G. Collingwood, Russell and Russell, New York, 1964, p. 26. To again quote Berlin: '…and whereas for those who contemplate the perfect society all ultimate values can be combined, like the pieces of a jigsaw puzzle, in this single, final solution, for Vico this cannot be so. For change – unavoidable change – rules all man's history, not determined by mechanical causes, as he thinks it is for the stoics or Spinoza, nor due to chance, as it is for Epicurus and his modern followers.' Isaiah Berlin, *Against the Current: Essays on the History of Ideas*, The Hogarth Press, London, 1980, p. 123.

[137] Reducing 'up' means the aggregation into homogenous wholes (i.e. the state as a black box), consequently, the number of actors within the international system are reduced.

[138] McMullin, 'The Impact of Newton's Principia', pp. 281-2.

[139] Jack Cohen and Ian Stewart, *The Collapse of Chaos: Discovering Simplicity in a Complex World*, Penguin, London, 1995, p. 239.

> the fact that the system obeys the same laws ... provides no reason to suppose that our neural apparatus is programmed to operate the same way in interpretation as in perception or in either as in the beating of our hearts. What I have been opposing in this book is therefore the attempt, traditional since Descartes but not before, to analyze perception as an interpretive process, as an unconscious version of what we do after we have perceived.[140]

However, the fact that Kepler 'got it right', by building 'on a presumed commonality of nature',[141] only added weight to the scientific revolution that was beginning to stir. It only served to bolster a paradigm in its infancy, culminating in the work of Newton. Consequently, the increasing acceptance of mathematical principles as a means of explaining phenomena can been seen to exacerbate the situation within the social sciences, whereby the reification of concepts often stems from notions of scientific, and by extension, mathematical certainty.[142] Being able to explain and predict the movement of celestial bodies was a feat to impress and to cement the superiority of rationalist position. However, it was not all to be plain sailing as, well before the French physicist Henri Poincaré attempted to solve the three-body problem,[143] Newton found himself struggling unsuccessfully to plot the motion of the moon.[144] This was difficult to reconcile, given that Kepler had supposedly worked out laws of planetary motion. The difficulty arose as even:

> Simple quantitative telescopic observations indicate that the planets do not quite obey Kepler's Laws, and Newton's theory indicates that they should not. To derive those laws, Newton had been forced to neglect all gravitational attraction except that between individual planets and the sun. Since the planets also attract each other, only approximate agreement between the applied theory and telescopic observation could be expected.[145]

[140] Kuhn, *Structure of Scientific Revolutions*, 2nd ed., p. 195. He continues 'What makes the integrity of perception worth emphasizing is, of course, that so much past experience is embodied in the neural apparatus that transforms stimuli to sensations.' ibid.
[141] McMullin, 'The Impact of Newton's Principia', p. 282.
[142] And here is built the future platform for Newton, the shoulders for him to stand upon. It was from this tradition that the Newtonian worldview as a means to understand the social world emerged.
[143] Henri Poincaré influence on the development of the non-linear sciences is discussed in Chapter Two.
[144] Renu Malhotra, Mathew Holman and Takashi Ho, 'Chaos and the Stability of the Solar System', *Proceedings of the National Academy of Sciences*, vol. 98, no. 22, 2001, p. 12342.
[145] Kuhn, *Structure of Scientific Revolutions*, p. 32. From this Kuhn notes that certainty of empiricism is somewhat undermined in that 'to classify that sort of work as empirical was arbitrary. More than any other

To press the point further, the motions of the planets are not as easily predicted over a geological time-scale, with recent research indicating that over 'giga-years' timescales that the evolutions of orbits emerge chaotically.[146] Part of the problem here is that human time-scales have helped contribute to the 'idea that simple laws of nature could exist', masking irregularities that most people would not normally consider.[147] However, for those who have converted to the paradigm, this information is often pushed or squeezed to one side. If the belief structure *generally* holds true then there is obviously little need to seriously consider challenges to it (not least forgetting that, in the Kuhnian sense, beliefs are not easily resigned). Further validation of a 'scientific law' is not always necessary because there is such a widespread acceptance that scientists develop theories that explain a range of phenomena, yet at the most formal level any number of theoretical understandings can be developed so as to be consistent and to create an intelligible understanding with the available data (with one scholar referring to this as the 'recognised Achilles' heel of Rationalism').[148] Given this, it should have been of little surprise that:

> so general and close is the relation between qualitative paradigm and quantitative law that, since Galileo, such laws have often been correctly guessed with the aid of a paradigm years before apparatus could be designed for their experimental determination.[149]

Traditional scientific methods hardened and strengthened the classical causality principle in such a manner that research would inadvertently churn out 'similar

---

sort of research, the problem of paradigm articulation are simultaneously theoretical and experimental. ibid., p. 33. See also Lugg, 'The Priority of Paradigms', p. 178. See also Kuhn, 'The Function of Measurement', p. 170.

[146] Malhotra, *et al.*, 'Chaos and the Stability of the Solar System', p. 12343. See also, for example, Richard A. Kerr, 'Does Chaos Permeate the Solar System?', *Science*, vol. 244, no. 4901, 1989, pp. 144-5.

[147] Wolfram, *New Kind of* Science, pp. 313-4.

[148] Barnes, 'Thomas Kuhn', p. 86. Take the 'The story of Galileo dropping balls off the Tower of Pisa, as a piece of myth, is a story about *changing* intuitions by inventing an ideal scientific world where regularities can be separated from the disorder of experience.' James Gleick, *Chaos: Making a New Science*, Sphere Books, London, 1987, p. 41.

[149] Kuhn, *Structure of Scientific Revolutions*, p. 29. James Gleick, *Chaos: Making a New Science*, Sphere Books, London, 1987, p. 41.

conclusions' that continue to be drawn from 'similar assumptions'.[150] Self-fulfilling environments of this sort can be sustained for very long periods of time, meaning schisms can develop when theory and 'reality' diverge significantly. This is particularly pronounced in the social sphere, where theorising can be trapped by a prevailing scientific culture for much longer periods. Conceivably, to explain this, it could be argued that it becomes increasingly difficult to translate the scientific to the social as science increases [151]its sheer abstraction, meaning that the lessons do not transcend nearly so easily. The general failure of Einsteinian theory, which has displaced much of Newton's work on dynamics, to take hold could similarly be attributed to such a phenomena.[152] This, of course, allows for a dialogue and exploration of the concept of nested paradigms, in which incompatible paradigms reside in close proximity.[153]

It is important to stress that the underlying argument does not stand as a polemic seeking to deride or attack the importance of mathematics. That abstraction cannot be avoided when theorising is certain. Mathematics has evolved as the primary scheme humankind has devised to catalogue discernable patterns, whether they be shapes, symmetries, or relationships. Given human consciousness, mathematics is inevitable.[154] This point has not gone unheeded by those who have previously ventured into scientific endeavours. In attempting to reconcile mathematical truths with proposition in the physical sciences Galileo displayed a nuanced understanding of the contingency of science when he attempted to strengthen the metaphysical underpinnings of the mathematisation of knowledge by putting forward that:

---

[150] Karl-Heinz Becker and Michael Dörfler, *Dynamical Systems and Fractals: Computer Graphics Experiments in Pascal*, trans. Ian Stewart, Cambridge University Press, Cambridge, 1989, pp. 237-8.

[151] Ilya Prigogine has noted that that the basic characteristics of Newton's laws; 'determinism and time symmetry – have survived'. Ilya Prigigone, *The End of Certainty: Time, Chaos, and the New Laws of Nature*, The Free Press, New York, 1997, p. 12.

[152] Kuhn, *Structure of Scientific Revolutions*, pp. 97-8.

[153] This point was made earlier in respect to 'rational hermeneutic inquiry' but the point stands alone with out necessarily resorted to this particular theoretical approach in its singularity. See Heelan and Schulkin 'Hermeneutical Philosophy and Pragmatism', p. 278.

[154] Barrow, *Impossibility of Limits*, pp. 142,192.

> Philosophy is written in this grand book, the universe, which stands continually open to our gaze. But the book cannot be understood unless one first learns to comprehend the language and read the letters in which it is composed. It is written in the language of mathematics, and its characters are triangles, circles and other geometric figures without which it is humanely impossible to understand a single word of it; without these one wanders about in a dark labyrinth.[155]

However, what cannot be escaped is that the ontological and epistemological assumptions about the world became ensnared in a dialectical conversation of self-reinforcement. This is not an unusual process, but it has resulted in framing conversations about the world as being linear, ordered, and ultimately, determinable. It was this worldview that slowly gained momentum before transferring into the social realm. And from this intellectual well flowed modernity and the possibility of a world explained by science and that which can be reduced to a mechanistic understanding.

The rudiments of the mechanical world best illustrate this point. It was common for Descartes to convey his physics as a form of mechanics. In respect to the causal relationship between matter, he essentially presented a 'mechanical philosophy'[156] that allowed for an understanding of the world as being akin to a machine. Further to this, it is a machine that could be controlled and understood by those who possessed the appropriate skills.[157] Critics of modernity certainly present an idealised notion, much like the images depicted in Charlie Chaplin's *Modern Times*, of a mechanistic understanding of society. Indeed, the much-maligned billiard ball model within IR theory is a perfect example of reified, mathematical and overly-mechanistic concepts being used to explain cause and effect between states in the international system.[158] Indeed, such theorising is testament to the fact

[155] Galileo quoted in Hall, *From Galileo to Newton*, p. 82.
[156] Peter Dear, *Revolutionizing the Sciences: European Knowledge and its Ambitions, 1500-1700*, Palgrave, Houndsmill, 2001, p. 98.
[157] Noam Chomsky, 'Language and Nature', *Mind*, vol. 104, no 413, 1995, p. 3.
[158] See, for example: Arnold Wolfers, 'Actors in International Politics' in William T. R. Fox, ed., *Theoretical Aspects of International Relations*, University of Notre Dame Press, Notre Dame, 1959, pp. 100-6; J. David Singer, 'The Level-of-Analysis Problem in International Relations', *World Politics*, vol. 14, no. 1,1961, pp. 81-82; Alexander Wendt, 'Collective Identity Formation and the International State', *American Political*

that mechanical and determinable understanding did not end with Descartes. Newton's work may well have displaced Cartesian theory. With the former's groundbreaking revelations on gravity[159] and the movement he inspired away from deduction to induction,[160] Descartes position was effectively replaced by Newtonian 'mechanics' and 'determinism'.[161] These ideas continue to hold sway, not only for its descriptive prowess, but for the aforementioned reduction to underlying axioms from which all is built (including the notion of the universe balanced in equilibrium[162]). Descartes's fellow Frenchman, Voltaire, openly admitted that Descartes's work had been superseded by that of the Englishman Newton[163] but for Voltaire it was Descartes who 'gave Sight to the Blind', and in doing so exposed the 'Errors of Antiquity and of the Sciences. The Path he struck out is since become boundless'.[164] Voltaire captures an important element in that a progressive link between the two schools of thought is often pursued.[165] Irrespective of some of the quite significant differences, Cartesian (and Galilean) influences have been conflated, by some, into a neat Cartesian-Newtonian

---

Science Review, vol. 88, no. 2, 1994, p. 392; John M. Hobson, 'The 'Second State Debate' in International Relations: Theory Turned Upside-Down', *Review of International Studies*, vol. 27, no. 3, 2001, p. 401; Kurki, *Causation in International Relations*, p. 133.

[159] Chomsky, 'Language and Nature', p. 3. See also Leonidas Montes, 'Newton's Real Influence on Adam Smith and its Context', *Cambridge Journal of Economics*, vol. 3, no. 4, 2008, p. 558. Interestingly, Newton's work on gravity was considered by some to be a return to a certain level of mysticism - gravity being an invisible force and all. Goldstone, 'Efflorescences and Economic Growth in World History, pp. 367-8. Indeed his theory 'was fought vehemently for more than a generation, unlike its main competitors, it demanded the introduction of an inexplicable force that acted directly upon bodies from a distance', Kuhn, 'The Function of Measurement', p. 184. See also Koyré, *Newtonian Studies*, pp. 57-9, 139-48 (Appendix B).

[160] Although this significant point is not always absorbed by positivist with the epistemological differences between empiricism and rationalism often blending.

[161] There lies much argument here, and debates between Newtonian and Cartesians continued well into the eighteenth century. See Dear, *Revolutionizing the Sciences*, pp. 164-7. Indeed, presenting them as two homogenous entities is erroneous in itself. ibid. p. 158.

[162] See Hans J. Morgenthau, *Politics Among Nations: The Struggle for Power and Peace*, 4th ed., Alfred A. Knopf, New York, 1967 [1948], p. 197. Discussed at length in Chapter Four.

[163] See also Koyré, *Newtonian Studies*, pp. 53-4.

[164] Voltaire, 'Des Cartes and Sir Isaac Newton', pp. 89, 92. Curiously, Voltaire could not make the admission without first noting that Newton had not 'ever had any Commerce with Women'. ibid. It should also be noted that it is certain that Newton studied Descartes work closely in his earlier research but evidence suggests he rejected his interpretation of ancient geometry upon which Cartesian constructivism was built. Domski, 'Construction and the Intelligible in Newton's Philosophy of Geometry', p. 1114.

[165] To contexutalise chronologically, Descartes (b. 1596 – d. 1650) published in the first half of the seventeenth century. Newton (b. 1643 – d. 1727) is located at the end of the seventeenth and into the early eighteenth (first publishing his *Principia* in 1687). Voltaire (b. 1694 – d. 1778) was a man of the eighteenth century (indeed, his death is often given as a marker for the end of the Enlightenment). Voltaire witnessed the interplay between Newtonian and Cartesian schools of thought. Cartesian (and Lebnizian) ideas held considerable sway upon the continent long after the publication of Newton's *Principia.* For a good overview of the interactions between Newtonians and so called anti-Newtonians in the eighteenth century see Elkana, 'Newtonianism in the Eighteenth Century', pp. 297-306.

position.[166] The influence felt in the social sciences can be explained by this general blending of the Newtonian and Cartesian schools (with particular reference to reductionism) that by the end of the seventeenth century, rationalism, the 'knowing *how*' to approach knowledge, had emerged as the central tenet for understanding human affairs.[167] In a sentence, '[r]ationality is linked to knowledge, and knowledge to science'.[168] The consequence of this vision of the world became comprehensively entwined in the imagination, so much so that the 'epistemological thrust' would condition 'the ontological account'.[169]

The paradigm had matured, and by the nineteenth century it gave birth to its very own demon. Pierre-Simon de Laplace held the conviction, if only in his dreams, that by using the equations devised by Newton, an 'Omnipotent Calculator' was theoretically possible; that is, the world became computable.[170] The French philosopher and mathematician will long be remembered for his deterministic demon; the passage reads:

> We ought then to regard the present state of the universe as the effect of its anterior state and as the cause of the one which is to follow. Given for one instant an intelligence which could comprehend all the forces by which nature is animated and the respective situation of the beings who compose it – an intelligence sufficiently vast to submit these data to analysis – it would embrace in the same formula the movements of the greatest bodies of the universe and those of the lightest atom ; for it, nothing would be uncertain and the future, as the past, would be present to its eyes.[171]

166 See, for example, Shelton A. Gunaratne, 'Thank you Newton, Welcome Prigogine: 'Unthinking' Old Paradigms and Embracing New Directions. Part 1: Theoretical Distinctions', *Communications*, vol. 28, no. 4, 2003, pp. 435-55.

167 Dear, *Revolutionizing the Sciences*, pp. 168-70. For an interesting point on reductionism, Cartesian dualism (which is extrapolated to encompass Galilean-Cartesian-Newtonian dualism) and monism vis-à-vis the emergent influences of Darwinian evolution, and the consequent impact upon scientific methodology, see David L. Miller, 'Novelty and Continuity', *The Journal of Philosophy*, vol 47, no. 13, 1950, pp. 370-373.

168 Roger Trigg, *Rationality and Science: Can Science Explain Everything?*, Blackwell Publishers, Oxford, 1993, p. 174.

169 Fuenmayor, 'The Roots of Reductionism', p. 424.

170 Toulmin, 'The Idol of Stability', pp. 329, 335. See also Prigigone, *The End of Certainty*, p. 11.

171 P.S. Laplace, *A Philosophical Essay on Probabilities*, 6th ed., Trans. by F. W. Truscott and F. L. Emory, Dover Publications, New York, 1951 [1825], p. 4. Barrow points out that Laplace's argument is often simplified to an extreme and he 'was not talking about *our* ability to predict the future of the heavenly bodies. He was talking about 'a mind'… [of which] the human intellect, [only] in the perfection to which it has

At the most abstract and theoretical level, the world was considered to be deterministic. Blended with the atomised and axiomatic approaches to the study of science, reason had in many senses become rationalism. Society was there to be solved.

Science of the Social

The idea of becoming a scientist of social phenomena, not least in the newly-created fields of sociology and economics,[172] was driven by the predictive power that had been unleashed by Newton. The after-effects of this significant cultural shift continue to linger, although lessened in respect to the hard methodological applications in the humanities and social sciences. Order and equilibrium continue to permeate, and one need only look to the rationalist-based theories within IR to realise that many of the assertions and arbitrary delineations continue to pay some sort of homage, however subtle, to the sciences. These fundamental principles are known by many names, homeostasis is an example, but it is difficult to ignore Steven Toulmin's description that:

> [f]rom Hugo Grotius and René Descartes until the First World War, the ideals of intellectual order and rational intelligibility current among European intellectuals emphasized *regularity, uniformity,* and above all *stability*. From this standpoint, the merit of Newton's *Principia* was to show that the solar system of which the earth is a member is a "demonstration" – a *paradeigma*, in the classic Greek –of an *intrinsically stable* system. This assumed

brought astronomy, a faint idea of what such a mind would be', Barrow, *Impossibility*, p. 49. 'Laplace himself only used this fiction to demonstrate the extent of our ignorance and the need for a statistical description of certain process. The problematics of Laplace's demon are not related to the question of whether a deterministic prediction of the course of events is actually possible, but whether it is possible in principle, *de jure*', Prigogine and Stengers, *Order Out of Chaos*, p. 75. Further, Prigogine and Stengers press, from a Kantian perspective his demon is 'the symbol of the scientific myth, is an illusion, but it is a *rational* illusion', ibid., p. 87. It is also interesting to note the correlation between what was occurring in the sciences and the politics of continental Europe as 'the Newtonian program – the reduction of all physicochemical phenomena to the action of forces … - had become the official program of Laplace's school, which dominated the scientific world at the same time Napoleon dominated Europe', ibid., pp. 66-7.

[172] This is explicitly in reference to the rise of positivism. In reference to sociology, see the section below on Comte. In reference to economics, Chapter Four details the Newtonian connection to classical and neo-classical economic thought, however, in direct reference to the impact of positivism upon economics see Caldwell, 'Positivist Philosophy of Science and the Methodology of Economics', pp. 53-76.

> success for Newton's theory convinced the 'Mathematical and Experimental Natural Philosophers' (the theoretical physicists of the seventeenth century who took a lead from Galileo Galilei, Johannes Kepler, and Descartes) that their use of Euclid's *Elements of Geometry* as a model for a new physics – or, for Thomas Hobbes, a political theory – was not a dream born of Platonist epistemology alone, but a realistic program for scientific research.[173]

Again, it is this *impression* of paradigms, shown above in its Greek root, which cannot be shaken. The meta-physical wanderings of searching for appropriate 'hooks' to assist in exploring and knowing what is 'out there' (the world) and what is 'in here' (the mind) had in certain respects been abandoned. The strength of the Newtonian paradigm is that through its reductionism it had shown the world what was real – in many instances it did this quite successfully or, at the very least, it gave the impression of success. It was because of this development that:

> [t]he mathematical method of deduction from axioms had a decisive effect on the social sciences of the Enlightenment. Newtonian physics reduced the apparently chaotic behaviour of matter in the universe to one simple principle, gravity, and a few simply and mathematically stated laws of motion. In the Enlightenment, everybody wanted to be the Newton of the social sciences.[174]

For the most prominent thinkers of the seventeenth century, 'the sole true method of discovery and of exposition' had become mathematics. 'Descartes and Spinoza, Leibniz and Hobbes' sought to banish any possibility of prejudice and superstition by assuring that what could be said should be said in 'quasi-mathematical terms' giving 'their reasoning a structure of a mathematical kind'.[175] However, the peak had not yet been reached. That would occur in the nineteenth century. Marx is a recurrent example, but the most favoured is the man considered to be the father of

173 Toulmin, 'The Idol of Stability', pp. 329-30.
174 J. S. McClelland, *A History of Western Political Thought*, Routledge, London and New York, 1996, p. 304.
175 Isaiah Berlin, 'Introduction' in *The Age of Enlightenment: Selected, with Introduction and Commentary*, Mentor Books, New York, 1956, p. 15.

positivism: Auguste Comte. Positivism, a term coined by Comte in the 1830s, encapsulated the outlook that there existed scientific underpinnings of what he viewed to be historical laws. It is this notion of an 'heroic science', the development of 'general laws out of direct observation of phenomena',[176] that underscored the initial development of a social science. Comte felt that positivism finally provided 'a complete and consistent whole'[177] and it is this 'law making' in the social sciences that, in the nineteenth century, sought to capture the advances of the Scientific Revolution and the rationalisms of the Enlightenment. E. H. Carr, who was not necessarily well-versed in the works of Newton or Galileo,[178] sought to debunk positivism hold when he argued that:

> The word 'law' came down trailing clouds of glory from Galileo and Newton. Students of society, consciously or unconsciously desiring to assert the scientific status of their studies, adopted the same language and believed themselves to be following the same procedure. The political economists seem to have been the first in the field with Gersham's law, and Adam Smith's laws of the market. Burke appealed to 'the laws of commerce, which are the laws of nature, and consequently the Laws of God'. Malthus propounded a law of population; Lassalle an iron law of wages; and Marx in the preface to *Capital* claimed to have discovered 'the economic law of motion of modern society'. Buckle in the concluding words of his *History of Civilization* expressed the conviction that the course of human affairs was 'permeated by

---

[176] Appleby, et al., *Telling the Truth About History*, p. 67. See also John D. Barrow, *Impossibility: The Limits of Science and the Science of Limits*, Vintage, London, 1999, pp. 45-8.

[177] Auguste Comte, *A General View of Positivism*, J.H. Bridges trans., Robert Speller & Sons, London, 1957 [1848], p. 7.

[178] Certainly no evidence exists in this text of having a familiarity with their work (arguably representative of how paradigms 'transcend'), however, mention is also made of French physicist Henri Poincare (in respect to the three-body problem – see Chapter Two) and much later Descartes, in reference to his overused *cogito, ergo sum* position. E. H. Carr, *What is History*, 2nd ed., Penguin, London, 1987, p. 58. In his preparatory notes for a later serious reworking of the original there is a tacit posthumous nod to the work of Vico (p. 159.), most likely via his correspondence with Isaiah Berlin (p. 157) from whence many of these notions may have been introduced. R. W. Davies, 'From E. H. Carr's Files: Notes Towards a Second Edition of What is History?', in Carr, *What is History.* Mention is made of 'Newtonian principles' in his seminal work *The Twenty Years' Crisis* (pp. 25, 63), there is, again, no evidence of familiarity with the *Principia.* To quote: 'Henceforth no political figure could ignore him [Machiavelli]. In France Bodin, In England Hobbes, in the Netherlands Spinoza, professed to find a compromise between the new doctrine and the conception of a 'law of nature' constituting a supreme ethical standard. But all three were in substance realists; and the age of Newton for the first time conceived the possibility of a physical science of politics', E.H. Carr, *The Twenty Years' Crisis 1919-1939: An Introduction to the Study of International Relations*, reissued with a new introduction and additional material by Michael Cox, Palgrave, New York, 2001, p. 63.

> one glorious principle of universal and undeviating regularity'.[179]

Epistemologically, an economic understanding of social systems can be traced from these sweeping (and, as always, selective) accounts of human interaction.[180] Effectively, this type of approach focuses on the core constituents of the systems, whether it is atoms in natural sciences, individuals in the social sphere, or states in the international realm, from which reductionism quickly follows. In the realm of economics, as is expanded upon in Chapter Four, the foundation of neoclassical economics is built upon a 'misunderstood model of mid-nineteenth century physics'.[181] The evocations of many influential Enlightenment thinkers are rooted in notions of equilibrium and mechanical explanations, the fundamental basis of this understanding stemming from the idea of an 'economic man' or the 'rational individual'.[182] This is, of course, built upon what was an emerging faith in scientific foundations for a theory of politics.[183] Noting the paradigm shift to a Newtonian view of the world, Kenneth Gergen supports Carr's sweeping assertions but, significantly, pushes that the excitement around the Newtonian approach contributed to the actual development and creation of the social sciences:

[179] E. H. Carr, *What is History*, 2nd ed., Penguin, London, 1987, p. 58. Carr acknowledges that the term 'law' had lost its resonance as concrete and indisputable. ibid., pp. 58-9. It is worth noting that he quoted the same Buckle quote in his earlier piece. See Carr, *The Twenty Years' Crisis*, p. 64. Although unpopular in the eyes of many scholars, the influence of Carr on the discipline, at least in the context of this thesis, is best captured by Friedrich Kratochwil, premising his article with the introduction that 'The best proof that E. H. Carr has written a true 'classic' is that *The Twenty Years' Crisis* provides much food for thought even now when some of its alleged foundational verities have become problematic. Rather than being limited to a 'realist' understanding of politics pure and simple, the reader encounters an analysis that is much more subtle though much less scientific than later realist interpretations would suggest. True, the first chapter is entitled 'The science of international politics' but the discussion about 'purpose', Carr's invocation of Marx, and the intellectual history he paints with a broad brush, make it clear that it is not a conception of natural science that informs his inquiry. Besides, as with every classic, different readings are possible', Friedrich Kratochwil, 'Politics, Norms and Peaceful Change', *Review of International Studies*, vol. 24, no. 5, 1998, p. 193.

[180] These ideas are expanded upon in chapters four and five.

[181] William T. Gangly, 'Institutional Economics and Neoclassicism in the Early Twentieth Century: The role of Physics', *Journal of Economic Issues*, vol. 24, no. 2, 1995, p. 398. Gangly also notes that this resulted in the rigorous mathematization of the discipline.

[182] Ruth W. Grant, 'The Ethics of Incentives: Historical Origins and Contemporary Understandings', *Economics and Philosophy*, vol. 18, no. 1, 2002, p. 125.

[183] Ball, *Critical Mass*, p. 70.

> Later, Newtonian mechanics largely replaced architectural structure and as the chief source of metaphors drawn from the inanimate realm. A system is mechanical in the Newtonian sense if it consists of discrete bodies, each possessing a specific set of properties (such as mass or weight) that act over space and time according to fixed laws. It was this law that prompted David Hume … and others to propose that the world is one great machine and to draw some historically significant conclusions from this propositions. Indeed, so many corollaries have been extracted from the machine metaphor that there is an important sense in which much contemporary social science owes its beginning to Newtonian mechanics. If the universe is one great machine, with lawful interdependence among its parts, then a certain form of social enquiry is clearly invited. Specifically, it becomes the task of social sciences to isolate and identify the parts of the social world and to discover the lawful relations among them. This was the task to which such social thinkers as Adam Smith …, Thomas Malthus … and Herbert Spencer … devoted themselves to before the emergence of systematic social sciences.[184]

It is important to reaffirm that some thinkers stand outside of this tradition. Hobbes, for example, presents as *sui generis* and cannot be banished or pushed aside by labelling him as a reductionist, as his 'at best probabilistic' position on 'natural history' is constructed not on ignorance of scientific development 'but because he is skeptical about its foundations and highly concerned with the structure of knowledge and its political implications.'[185] Yet a desire to incorporate Newtonian principles to some degree did emerge in the eighteenth century. To differing degrees this was undertaken by members of the Scottish Enlightenment, notably Hume and Smith but also, earlier, by the Englishmen John Locke (who regularly corresponded with Newton). Although not looking to create an actual

[184] Kenneth J. Gergen, 'Metaphor, Metatheory, and the Social World' in David E. Leary, ed., *Metaphors in the History of Psychology*, Cambridge University Press, Cambridge, 1994, pp. 279-80.

[185] Michael C. Williams, 'Hobbes and International Relations: A Reconsideration', International Organization, vol. 50, no. 2, 1996, p. 224. By 'natural history' Hobbes meant 'experiential knowledge'. ibid. Further 'In sum, Hobbes is not a mistaken reductionist whose analyses reflect a more general realist failing to understand adequately the nature of scientific explanation. Nor, paradoxically, is he an advocate of a positivist-inspired science of international politics as some so-called critical theorists recently have averred. His stance is a result of a rejection of both of these theoretical alternatives.' ibid. That said his respect for Euclidian geometry as a form of truth should not be overlooked entirely: "But take on a truth that in Geometry, (which is the only science that it hath pleased God to bestow on mankind,) me began at settling the signification of their words." Thomas Hobbes *Leviathan*, C. B. Macpherson, ed., Penguin Books, Harmondsworth, 1968 [1651], pt. I, ch. ii, p. 105.

'science of politics', he shared the sentiment of establishing general rules that bore a reflection to science, of which Newton's mechanics and optics were 'the highest exemplification of those general rules'.[186] That said, and with Smith thought of by some as a father of political science,[187] it is not difficult to imagine how reductionism, under the guise of rationalism, emerges as an epistemological starting point. For example, in the area of sociology, 'one of the few general theories applied (particularly by Smith and Hume) is the rational choice model, "the economic model of man" or "utilitarian theory"'.[188] It is not difficult from this vantage-point to envisage how these ideas flowed into Comte's nineteenth century; a period recognisable by the ascendancy of mathematised economic equivalents, averages and agents that were beginning to inform, define and direct debate. Indeed, at the more extreme end, the study of political, social and economic systems reached new grounds of social determinism. Essentially, 'economic man' and the social physics of Adolphe Quetelet built upon *l'homme moyen* converged so that an understanding of society could be reduced to and averaged out to the conception of the 'average man'.[189]

The diverse and varied nature of Enlightenment thinkers (and a considerable number who came before and after) does little to dilute the general disposition that rationalism borne of science offered definitive answers to problems in the social world. The application of Newtonian methods to metaphysical dilemmas resulted in dominance of a material understanding of the world in which

[186] James Farr, 'Political Science and the Enlightenment of Enthusiasm', *American Political Science Review*', vol. 82, no. 1, 1988, p. 53.
[187] ibid., p. 51
[188] Karl-Dieter Opp quoted in Milan Zafirovski, 'The Rational Choice Generalization of Neoclassical Economics Reconsidered: Any Theoretical Legitimation for Economic Imperialism?', *Sociological Theory*, vol. 18, no. 3, 2000, p. 452. This is of course dependent upon the paradigmatic viewpoint from which these two authors are interpreted, particularly those seeking a lineage for their discipline. This is especially true of Hume who obviously influenced the work of Smith. Sheila C. Dow 'Interpretation: The Case of David Hume', *History of Political Economy*, vol. 34, no. 2, 2002, pp. 399-403.
[189] Ball, *Critical Mass*, pp. 77-80. What has been referred to as 'the crossed fingers of positivist explanation', the idea that all things might be equal. Charles Dyke quoted in Michael Shermer, 'Exorcising Laplace's Demon: Chaos and Antichaos, History and Metahistory', *History and Theory*, vol. 34, no. 1, 1995, p. 64. The idea of economic determinism is pursued at length in Chapter Four.

universal order prevailed.[190] Again, despite deductive and inductive differences,[191] much of this can be traced to Descartes, who wished to 'discover a practical philosophy' so as to promote the 'general good of mankind'.[192] Using that as a beginning point, as has been shown, this general philosophical attitude flowed relatively freely into the nineteenth century. Thinkers like Comte, Buckle and Condorcet were a product of this tradition that ushered in the emergence of a positivist social science, one which sought to pass on 'a stock of law-like generalizations with strong predictive power',[193] an influence that was both reticent in respect to critical reflection and dominating in its ability (or at least arrogant in its belief of dominance) to push alternative positions to the peripheries for being 'unscientific'.

Bertrand Russell, who emerged from the positivist tradition, remembered the enthusiasm for the possibility of 'a mathematics of human behaviour as precise as the mathematics of machines'.[194] He, of course, moved away from such determinism, but he was not the first to have mixed ideas in respect to the certainty of science. Vico was put forth earlier, but David Hume presents curiously in this regard. His empiricism, enshrined in his 'experimental method', did seek to replicate Newton's advances in the sciences. Indeed, he sought to 'become the

---

[190] Ernst Cassier, *The Philosophy of the Enlightenment*, trans. Fritz C. A. Koelln and James P. Pettegrove, Princeton University Press, Princeton, 1955, p. 8. Indeed, Cassier notes, linking in with the following section, that 'no such conflicting modes of validity, no such dualism between "relations of ideas" and "matters of fact" as we find in Hume's *Enquiry concerning Human Understanding*, is to be found among the Newtonian thinkers', ibid.

[191] Remembering, as stated earlier, that Newton and Newtonian do not necessarily mean the one and the same.

[192] Descartes, *Discourse on Method*, Part VI, p. 46.

[193] Alisdair MacIntyre, *After Virtue: A Study of Moral Theory*, 2nd ed., Duckworth, London, 1985, p. 88. However, even the fixed notion of a 'scientific revolution', inasmuch as the Enlightenment is considered a homogenous and sudden occurrence, is an overstatement. Of course, the Enlightenment is not a singular story of the march of reason and rationalism, in actuality the movement away from the 'dark ages' transpired in fits and starts. The emergence of methods of reasoning and experimentation that are now recognised as 'scientific' occurred slowly and in many instances grew from as much as they split from traditions, both western and non-western, from areas as diverse as alchemy, astrology and theology to areas that we now recognise as science like astronomy, medicine and zoology. Goldstone, 'Efflorescences and Economic Growth', p. 368. In addition Goldstone expands his point to incorporate similar notion the have surrounded common perceptions of the Industrial Revolution. Yet, the dominance in the thought of Newton and Comte upon the social has dirtied the waters of the Enlightenment, as a closer look at many at many of these scholars reveals that in most cases 'a much richer psychology than that expressed in the mechanical axioms of contemporary economic rationality' Grant, 'The Ethics of Incentives', p. 125.

[194] Russell quoted in Carr, *What is History*, p. 56.

Newton of the moral sciences'[195] and his respect for the natural science was well noted.[196] He was convinced that not only could politics be reduced to a science but that 'the social sciences were capable of the same degree of certitude as the physical sciences'.[197] In an early essay he argues 'that politics may be reduced to a science'. He suggests that politics can be reduced to government and laws, to the extent that irrespective as to the nature of men general consequences may be deduced similarly as can be done in the mathematical sciences.[198] His position is reminiscent of a Burke or a Montesquieu. Even his subtitle of the *Treatise of Human Nature*, 'An attempt to introduce the experimental method of reasoning into moral subjects', is heavy in irony in that Hume, although an empiricist, effectively used the tools of the Enlightenment to discredit reason as a pure method of rational analysis.[199] Then, in addition, on causation, linkages in Hume's work appear to embody linear determinism. This is most pronounced when he draws on the example of billiard balls (allowing for easy comparison to the billiard ball model in IR), suggesting that the effect of one ball upon another is a 'constant conjunction betwixt the cause and effect' and, importantly, noting that 'Every object like the cause, produces always some objects like the effect'.[200] These dynamics seem to transcend to the realm of humankind when he asserts that:

> It is universally acknowledged that there is a great uniformity among the actions of men, in all nations and ages, and that human nature remains still the same, in its principles and operations. The same motives always produce the same actions: The same events follow from the same causes.[201]

---

[195] Philip Ball, *Critical Mass: How One Thing Leads to Another*, Arrow Books, London 2004, p. 69.
[196] Berlin, 'Introduction' in *The Age of Enlightenment,* p. 16. Indeed, Onuf represents Hume as 'being a major source of positivism'. Nicholas Onuf, *World of Our Making: Rules and Rule in Social Theory and International Relations*, University of South Carolina Press, Columbia, 1989, p. 186.
[197] Sheldon S. Wolin, 'Hume and Conservatism', *American Political Science Review*, vol. 48, no. 4, 1954, pp. 1004-5.
[198] David Hume, 'That Politics May be Reduced to a Science', *Selected Essays*, Oxford University Press, Oxford, 1996 [1741] p. 14. See also Ball, *Critical Mass*, p. 69.
[199] Wolin, 'Hume and Conservatism', p. 1001.
[200] Hume quoted in Tom Beauchamp and Alexander Rosenberg, *Hume and the Problem of Causation*, Oxford University Press, New York, 1981, p. 4. See also Kurki, *Causation in International Relations*, pp. 35-7.
[201] Hume quoted in Leon Pompa, *Human Nature and Historical Knowledge: Hume, Hegel and Vico*, Cambridge University Press, Cambridge, 1990, p. 42.

Hume, when considering the overall corpus of his work, was masterful in his own narrow scope, yet in isolation the above quote depicts linear determinism comparable to that of Laplace. However, his conception of human nature – that is the role of the passions – tempers accusation of this kind.[202] The passions are a widely noted theme that emerges from much of his work and the appeal to his oft-quoted axiom that 'reason is, and ought only to be, the slave of the passions',[203] where the 'sentiments' rule the minds of men. However, one of the real curiosities that emerge from his overall corpus is the teleological indeterminism that, given the perceived mechanistic nature of science of that period, is unusual. Hume, for all intents and purposes, undermines deterministic notions of predictable outcomes in human affairs when, much later, he notes, again after asserting the roles of the passions, that:

> We are placed in this world, as in great theatre, where the true springs and causes of every event, are entirely concealed to us; nor have we either sufficient wisdom to foresee, or power to prevent those ills, with which we are continually threatened. We hang in perpetual suspence between life and death, health and sickness, plenty and want; which are distributed amongst the human species by secret and unknown causes, whose operation is oft unexpected, and always unaccountable.[204]

Further to this, Hume argues (and here one can sense shades of Vico being present) that 'the science of man is the only solid foundation for the other sciences'.[205] A more substantive study of Hume is not the intention laid out within this thesis but his worldview, which at a rudimentary level appears paradoxical,

[202] ibid. For Peters it is from the well of determinism that natural law flows. Edgar E. Peters, *Fractal Market Analysis: Applying Chaos Theory to Investment and Economics*, John Wiley & Sons, New York, 1994, 7.

[203] David Hume, *A Treatise of Human Nature: Book II: Of the Passions*, edited, with analytical index, by L.A. Selby-Biggs, Clarendon Press, London, 1888 [1739], p. 415. Selectively channelling Vico Hume also puts forth that 'Mathematics, indeed, are useful in all mechanical operations, and arithmetic in almost every art and profession : But 'tis not of themselves they have any influence', ibid. p. 413. Wendt also notes the Humean link to the passions but seeks to move beyond the 'dualism of desire and belief' and searches, instead for a 'cognitive theory of desire'. Wendt, *Social Theory of International Politics*, p. 119. On this last point, see Chapter Five.

[204] David Hume, *The Natural History of Religion*, edited with introduction by H.E. Root, Adam & Charles Black, London, 1956 [1777], p. 28.

[205] Hume, quoted in Heikki Patomäki and Colin Wight, 'After Postpositivism? The Promises of Critical Realism', *International Studies Quarterly*, vol. 44, no. 2, p. 219 It is felt that Hume would most likely have encountered Vico's writings .

suggests an implicit and probably unrecognised appreciation for the role of indeterminism and conjecture within certain parameters (a position easily aligned with non-linear theories).[206] Hume seeks a scientific understanding, but it is based upon a 'contingent empiricism' (built on his causal claim linking 'ideas' and 'impressions') that runs at odds with the positivist tradition.[207] This is not to say that Hume stood alone, or represents a father figure of a particular movement that rose in opposition; it is more a case of recognising a giant within the Western philosophical tradition and a supporter of scientific analysis of the social who did not fall completely under the spell of the Newtonian paradigm.

Despite such objections, the Newtonianism and the determinism that had been unleashed remained the currency of the day. Determinism, as found in the work of Hegel, or Marx, who turned him 'on his head',[208] can be seen to have been constructed from these foundations. In essence, science and human reason surfaced from this new period of intellectual exploration with claims of universal laws, predictability, and order.[209] The determinism of Marx is easily laid bare:

> The idea of progress, historicism, and a scientific history seemed to come together in Marxism. Here was a vision of history informed by a heroic science that offered a concrete social and economic model of the meaning of progress (triumph of one mode of production over another), that sought the laws of change within the process of history itself (and thus was historicist), and that claimed a scientific status for the inexorable workings of social laws (and thus was determinist). Marxism also seemed to make revolutions inevitable and endorsed their benefits.[210]

---

[206] The importance he attributes to the passions can also be seen to tie into the concepts of emergence and sensitive dependence to initial condition, topics to be more fully explored in Chapter Three.

[207] Alexander Rosenberg, 'Hume and the Philosophy of Science', in David Fate Norton, ed., *The Cambridge Companion to Hume*, Cambridge University Press, Cambridge, 1993, p. 67. Indeed, he pulls the rug out from under the 'rationalist claim that there is an *a priori* route to reality', Berlin, *Against the Current*, p. 7.

[208] For Marx, the dialectic is informed by material conditions as opposed to ideas. See, for example Baldwin Ranson, 'Rival Economic Epistemologies: The Logics of Marx, Marshall and Keynes', *Journal of Economic Issues*, vol. 14, no. 1, 1980, p. 82.

[209] Geyer, 'Globalization, Europeanization, Complexity', p. 564.

[210] Appleby, et al, *Telling the Truth About History*, p. 71.

This interpretation of Marx is common, and he is often one of the most maligned for establishing a political theory that cements expectations with such deterministic flair and certainty. He was not to any degree the only political (or moral) philosopher to attempt feats of this nature; one need only look towards the rationalistic social contract of Locke,[211] Montesquieu's laws,[212] or Hegelian notions of freedom. However, Marx is most easily targeted. Jürgen Habermas, for one, was critical of Marx's (despite ambiguities) scientific approach to society. This was particularly evident when Habermas quipped that if Marx's 'iron laws' will result in the transition from capitalism then there is little need or necessity to become a Marxist in the first place. For Habermas, Marx ignores reflexivity,[213] and this is where some of the undoing begins. The small threads of discontent that had been directed toward social determinism were gaining momentum and were becoming more difficult to 'suppress'. Depending upon interpretation, Hume's indeterminism, irrespective of its importance to his overall body of work, was, for some, to be looked on more favourably. To take a modern IR theory concept like balance of power, for example, it is not difficult to argue that the balance lies in the mind and is placed upon reality.[214] States are comprised of human elements that are driven by what Hume refers to as the passions. It represents the Humean duality of desire and belief contingently (and conveniently) constructing an understandable idea or impression of the world.[215] Illustrated is the point that heroic ideas of science in the social realm cannot then be said to undermine the passions. This is, of course, not a rejection of reason, but a move away from a reduced understanding of affairs.

During the nineteenth century, when positivism was at its peak, other thinkers, mainly French, were similarly beginning to move away from the dominant

[211] In his seminal text Locke refers to 'the incomparable Mr. Newton', John Locke, *An Essay Concerning Human Understanding* in Berlin, *The Age of Enlightenment,* p. 33.
[212] Which Berlin referred to as 'Montesquieu's notorious 'spirit' of the laws', Isaiah Berlin, *The Proper Study of Mankind*, pp. 53-4.
[213] Giddens, 'Jürgen Habermas', pp. 124-5.
[214] Patomäki and Wright, 'After Postpositivism?', p. 220. Hume and the notion of balance of power are pursued further in Chapter Four.
[215] Wendt, *Social Theory of International Politics*, p. 119. On the state as an aggregate see Chapter Five.

paradigm (being French this usually meant Descartes over Newton) in favour of Vico.[216] Tocqueville was identified by Roger Boesche as such a thinker, an individual who developed a keen ability to analyse and think about social community without the desire to reduce or abstract to attain understanding. Tocqueville's ability to 'predict' lay in his belief that society in its entirety is part of a dynamic whole that interrelates at all levels. For him nothing should be considered to be an 'isolated fact' as 'each individual mirrors and illuminates the whole'.[217] Indeed, in stepping away from the cosmology of thinkers like Newton, or even social thinkers like Locke, Tocqueville was able to consider alternatives to understanding the human world that did not rely upon causality, the 'immense chain of cause and effect' that so defined the natural sciences of the period. [218]

Conclusions

The compartmentalisation of knowledge, the classification and the bringing of order to how knowledge is approached may well be a necessary evil; the human mind needs to reduce the staggering complexity of the world, at some level, so that it may comprehend. But the hardening of disciplinary boundaries so that order may prevail has both assisted in constituting what is worth knowing within those fields (with a limited recognition of what occurs outside of them) and, secondly, cemented the boundaries of the dominant paradigm.

However, when the ideas first starting gaining traction, as the Newtonian outlook developed, it knew few bounds as it revolutionised approaches right across the academic spectrum. The tide that culminated in Newton, and was driven by his disciples that followed, surged through the loose confederations that were academic disciplines in their infancy, bringing the 'light' and delivering them from darkness. As this unprecedented king tide slowly receded, rock pools of knowledge started to form. Academic life within these microcosms was more

[216] Roger Boesche, 'Why Could Tocqueville Predict So Well?', *Political Theory*, vol. 11, no. 1, 1983, p. 80
[217] ibid., pp. 80-1 Although Gaddis feels quite differently about Tocqueville's ability to predict. Not that he did not predict well but that correlation and cause did not always match, with his predictions being fortuitous as opposed to insightful. Gaddis, 'In Defence of Particular Generalizations', p. 314.
[218] Boesche, 'Why Could Tocqueville Predict So Well?', p. 84.

often than not vibrant and robust as researchers pursued, argued for or were critical of developments within their own rock pools, contributing significantly to their own respective fields. The problem was that it became difficult to communicate new ideas between the different pools. Some ideas made the transition, mimicking smaller tidal movements, but on the whole disciplines became self-contained. Conversely, they remained at the meta-theoretical level, to some degree, self-similar (like fractals) as they continued to be framed by the light (read paradigm) that stemmed from the original Newtonian king tide.

For those prone to such sensibilities, this served well. It was neat, it provided order, predictably and an unparalleled level of understanding that did not necessarily have to appeal to the heavens in order to provide explanation. If a problem was yet to be solved, the *belief* was that it could be worked out. The illusion that chaos, in time, would be driven from human understanding and experience was nourished continuously.[219] The remainder of thesis is devoted to illustrating that chaos never left. Overturning a paradigm is not an easy task but pressure is starting to bear on the rationalist position, for one this chapter has shown that not all thinkers swallowed the rationalist medicine. Vico's return to popularity has been secured by this unease and what could be viewed as the beginning of a shift between paradigms. But it was Kuhn who awakened many with his paradigmatic theory that:

> [u]ncompromisingly and comprehensively undermines the rationalist account of science. It repudiates the power of an autonomous individual reason; it rejects an individualistic account of research: and it denies that scientific change is a gradual evolutionary progression.[220]

[219] Heinz-Otto Peitgen, Hartmut Jürgens and Dietmar Saupe, *Chaos and Fractals: New Frontiers of Science*, Springer-Verlag, New York, 1992, p. 11.

[220] Barnes, 'Thomas Kuhn', p. 94. 'Contrary to what is often alleged, Kuhn does not hold that the rationalist conception of scientist following rules ought to be replaced by a nonrationalist conception of scientists pursuing social interests and responding to social pressures. His aim is not to subordinate reason to tradition but rather to remind us that reason is itself a particular (albeit rather special) tradition.', Lugg, 'The Priority of Paradigms', p. 179.

This is not to suggest that the 'Newtonians', for want of a better term, are beating a hasty retreat. The attempt to plot human societies as if they were stuck in some form of planetary orbit has certainly passed. But the belief in reductionism as a means to discover generalised assumptions still weighs heavily across most academic fields.

A recent example of this pursuit from within IR theory is to be found in Bradley Thayer's work, where he emphatically states that evolutionary theory will allow us to 'realize Condorcet's dream of a unified natural and social science for the first time', breathing life back into Condorcet's hope for an exact science that studies 'the societies of bees or beavers'.[221] Not wanting to leave any stone unturned he also declares that 'we' are entering the 'century of biology' and Darwin represents 'the Robespierre or Lenin of this revolution'.[222] In respect to structural realism, Thayer finds IR theorist and structural realist Kenneth Waltz to be an improvement on classical realism as it is 'more scientific', concluding that evolutionary theory can improve the structuralist approach because 'it places the theory on a scientific base for the first time'.[223] There is nought wrong with looking to the evolutionary science to inform an understanding. There exist wide-ranging linkages between evolutionary theory and the non-linear sciences, but for Thayer it is not a case of seeking a more illuminated path beyond what is already 'known'. Effectively, it is a repackaging as opposed to a re-imagination; Thayer is an unashamed reductionist who changes his 'Newtonian' hat for the 'Darwinian', all the while remaining part of the dominant scientific paradigm.[224] The aim is to create (or rather continue the process) a science of IR built upon axiomatic principles and the prevailing notion of an ordered equilibrium-finding universe.

---

[221] Berlin, *The Proper Study of Mankind*, p. 20.

[222] Bradley A. Thayer, *Darwin and International Relations: On the Evolutionary Origins of War and Ethnic Conflict*, Kentucky University Press, Kentucky, 2004, 425, pp. 1, 9.

[223] ibid. pp. 64-5.

[224] Indeed, during the twentieth century evolutionary theory was neglected in favour for 'synchronic and ahistorical modes of social analysis' as 'sociologist and political scientist turned en masse to a strangely ahistorical Cold War science'. What Thayer can be seen to represent is the 'genetic reductionism in the ultra-Darwinism of such scholars as Richard Dawkins', David L. Harvey and Michael H. Reed, 'The Evolution of Dissipative Social Systems', *Journal of Social and Evolutionary Systems*, vol. 17, no. 4, 1994, pp. 371, 392.

In this respect, Newton is still king. It is the *reverence* towards his magisterial positions within the Western philosophical and scientific canon that needs to be exposed as opposed to overturned. To quote John Maynard Keynes:

> In the eighteenth century and since, Newton came to be thought of as the first and greatest of the modern age of scientists, a rationalist, one who taught us to think on the lines of cold untinctured reason … I do not see him in this light.… Newton was not the first of the age of reason. He was the last of the magicians, the last of the Babylonians and Sumerians … the last wonder-child to whom the Magi could do sincere appropriate homage.[225]

Newton as the magician generates a different image, an image that brings to the fore the paradigmatic nature of our scientific belief structures. Again this does not diminish the success within fields that have garnered knowledge from the Newtonian fountain (where would engineers be?) but it does allow for the questioning of what scientific paradigms offer when imagining social spheres. At the very least what is being proffered is a movement away from a nineteenth century ontology that continues to mould, inform and influence approaches within the social sciences. In this respect Toulmin makes another noteworthy contribution when he questions why the Newtonian program was undertaken:

> 'Why was the type example of serious Science – to be emulated by economists, sociologists and psychologists no less than by physiologists and biochemists –Newtonian Dynamics? Why were the first human scientists so determined to be the *Newtons* of social theory?' Surely, the activities of human beings are not like the motions of planets in their orbits, or rigid spheres rolling down inclined planes? Surely, they are far more like the behaviors of living creatures? … No work in the natural sciences had greater influence on the idea of 'theory' in the social sciences than Isaac Newton's *Principia* – at least as these are interpreted in

[225] John Maynard Keynes quoted in Cohen, 'Newton in the Light of Recent Scholarship', p. 492. When asked why he called Newton a magician Lord Keynes replied 'Because he looked on the whole universe and all that is in it *as a riddle*, as a secret which could be read by applying pure thought to certain evidence, certain mystic clues which God had laid about the world to allow a sort of philosopher's treasure hunt to the esoteric brotherhood'. ibid.

our universities – yet no work … has been more deeply misunderstood.[226]

Confronting this misunderstanding is the task laid out in the remainder of what is written here. Ideas, truths, and paradigms will be shown to be nested and that the dominance subscribed to a particular worldview can shift suddenly, challenging long-held meta-theoretical assumptions. Like the avalanches in a large pile of sand,[227] the shifts are unpredictable and vary in size but critical points are reached. A critical mass, a tipping point,[228] or a punctuation of equilibria: the terms vary depending upon the disciplinary field, yet what they represent is a move away from linear analysis to embrace a more unpredictable and holistic vision of the world. What is argued henceforth is that a new tide, not quite the king tide that Newton embodied, but a tide of significant size is offering an alternative view of the world, and, most importantly, facilitating communication between the various rock pools.

[226] Toulmin, 'The Idol of Stability', p. 328.
[227] See self-organised critically in Chapter Three.
[228] On tipping and its relation to feedback and complexity it is worth noting that even 'In the simplest cases, tipping occurs as actors respond to their new environments without behaving strategically or drawing inferences about how others will behave. Greater complexity can be introduced by considering how actors estimate how others are likely to respond to changes and how they can seek to manipulate these responses… A third layer of feedback can operate if the changes alter people's preferences.' For example, a protest movement may gain momentum 'if the original and limited movement leads many bystanders to alter their views not only about the chance of success, but also about the legitimacy of the cause.' Jervis, *System Effects,* p. 151. See also John Urry, 'The Complexities of the Global', *Theory, Culture and Society*, vol. 22, no. 5, 2005, p. 240.

2

Chaotic Beginnings: Comprehending through a Fractal Lens

So Nat'ralists observe, a flea
Hath smaller fleas that on him prey,
And these have smaller yet to bite'm,
And so proceed, ad infinitum[1]

Chaos and order have defined human societies from the earliest of times, both having manifested across time and space with a diversity of conceptualisations. The Western experience, driven by the Scientific Revolution and the Enlightenment, was captured by the desire for order and drove the wedge of traditional linear science between the rational and the irrational. It is argued here, through the introduction of chaos theory, that the rise of non-linear science has challenged this dichotomy and, with it, scientific imagination. Following on from the last chapter, the importance of how a scientific worldview shapes understanding in the social sphere is emphasised. In doing this, the chapter maps

[1] Jonathan Swift quoted in Mandelbrot, *The Fractal Geometry*, p. 402. See also Gleick, *Chaos*, p. 103 and John Briggs, *Fractals: The Patterns of Chaos: Discovering a New Aesthetic of Art Science and Nature*, Simon & Schuster, New York, 1992, p. 41.

the movement away from the traditional linear and reductionist approaches that are enshrined as part of the Newtonian paradigm, towards the non-linear sciences that reached a populist zenith with the explosion of chaos theory upon the scientific imagination during the 1970s and 1980s. Yet before taking that particular path, the very idea of chaos, its roots, its meaning, and the impact it has had on the imagination within societies is explored. Chaos is all too often depicted as the antithesis of order and that which was pushed aside by the Newtonian paradigm, which, it was argued in the last chapter, had so captured the Western imagination. In doing this, the aim here is to stress the importance of imagination as a fundamental component of understanding the world around one, and it is argued that imagination need not be divorced from science. This line of argument is pursued because the study of social systems, like the international, are analogised and understood through the lens of the dominant paradigm: the permeation of the imagination by science, and science by imagination, is in itself a dialectic relationship that cannot be escaped.

Again, this is not to deny the role of science in contributing to explain the physical and social world (it does and it will continue to do so), but it is a case of accepting the inherent historicism tied to any theory of science. In accepting the rudiments of such a position it is important to recognise that ruptures do, and will, occur, thereby placing paradigms under pressure, and the manner in which the world is imagined is queried. Here lies the second aim within the chapter: examining how 'chaos', the notion of disorder and randomness, became a perceived scientific theory in its own right. Many of the lessons and underlying principles of chaos theory have drifted under the more robust umbrella discipline of non-linear science (incorporating complexity theory) and are explained at greater length in Chapter Three. Focusing on revealing a different perspective, this chapter deals with the rapid ascendancy of chaos theory as a means of visualising and giving shape to the chaotic, and it does so by tracking the gradual progression that culminated in Benoit Mandelbrot's development of fractals as a useful means of understanding and incorporating 'chaos'.[2] The fractal lens is pushed as a new perspective as an illustration, through this new geometry, that order emerges out of chaos. [3] Order is indeterminate and is a part of chaos (and vice versa). It is important to remember that chaos theory is or, depending on one's perspective, was so much more than just computer-generated fractals. However, fractals prove a very effective approach as they embody a significant essence of what the chaos 'revolution' represented, no less than the visual representation of the mathematician's mind.[4] Chaos, which for so long was depicted as something to be banished from the Western psyche, seemed to be making a triumphant return as it entered not only into the scientific imagination but also into the popular idiom.

Just as the Romantics sought to respond to how the world was *imagined* when under the sway of Newtonianism, so too have a myriad of artisans of differing persuasions and from a range of periods following the Scientific Revolution.[5] However, this level of intentionality is not always necessary, it is argued that artistic minds have, even at the most implicit levels, accommodated and welcomed chaos and disorder.[6] This is also true of those who attempted to push fractal imagery as a form of art, blurring the line between art and science. Writing during the Cold War in a divided Germany, 'chaologists' (a terribly conceived term if there ever was one) Heinz-Otto Peitgen and Peter Richter lamented that the 'cool rationality of science and technology has pervaded and transformed the world to such an extent that it could destroy human life. The inspiration of the arts can only respond helplessly, with bitterness'.[7] For Peitgen and Richter the science of fractals was also the art of fractals, seemingly a direct affront to the maintenance

[2] Mandelbrot, an eclectic academic, coined the term fractal (see below). Fractals are computer-generated images where infinitely complex patterns emerge from simple underlying rules. One can zoom in to or zoom out of a fractal but it will maintain its integrity and self-similarity. See Mandelbrot, 'Fractal Geometry: What is it', pp. 21-87 and Mandelbrot, *The Fractal Geometry of Nature*, passim.

[3] Mandelbrot, 'Fractal Geometry: What is it', p. 4.

[4] Other significant lessons, from chaos that have transcended so that they now reside under the 'complexity umbrella' are pursued in the following chapter, i.e. sensitivity to initial conditions.

[5] Goya, as detailed below, is an obvious example.

[6] Nor is this revelation contained purely to artisan working after the impact of Newton's *Principia*. It is not necessarily an oppositional point, but an acknowledgement that the artistic mind is rarely contained by neat, orderly and linear interpretations of the world.

[7] Peitgen and Richter, *The Beauty of Fractals,* p. 1.

of the traditional divide between art and science. Many debates have raged, and continue to do so, across this divide, a chasm that for many has come to represent the large gap between modern and post-modern ways of seeing. This is an unfortunate characterisation, as it is a misrepresentation of what science *is* that misinforms the debate. Both sides of the modern and post-modern divide adhere equally to the notion of what science (and consequently knowledge) is or is not.

This leads to the final element within this chapter, as it looks to how a fractal understanding of the world has long been implicitly a part of human understanding. As is argued below, 'man-the-artist' has been contemplating fractal-like notions for millennia, whilst 'man-the-scientist' is only beginning to tackle them.[8] In this sense, chaos theory is shown to be an important development. It has challenged Newtonianism, it has allowed the imagination to become reinspired when contemplating the 'serious' and the 'scientific', the realm where only the cold abstractions of reason were thought to prevail.[9] However, and ultimately, the chapter argues that in its purely scientific guise, 'deterministic chaos' is unhelpful in explaining the complexity that emerges in social, and other, systems. Its influence will be shown to have inspired, and to have set in motion the paradigmatic pressure of opening cracks and allowing new avenues of research. The importance and the usefulness of the chaos turn is to be appreciated through the advances of the complexity sciences, as will be explored in the following chapter. What chaos offers, either through a scientific or a socio-cultural lens, is a substantive re-imagination of the world via an alternative paradigm.[10]

Beginnings

The very notion of chaos has permeated the Western imagination for millennia, the root of the word, as with many other terms, originating in ancient Greece. It derives from the Greek χάος (xaos), which in itself is drawn from *Λχα* (ligha),

[8] Mandelbrot, 'Fractal Geometry: What is it', p. 9.
[9] The abstraction and the mathematisation of the world was discussed in the previous chapter. The return of intuition to the study of international relations is discussed in Chapter Five.
[10] The argument drives towards exposing the reductionist and linear poverty of dominant rationalist approaches within IR theory. See chapters four and five.

which described a 'yawning space or gap'.[11] The Oxford English Dictionary lists, as its first definition, that chaos is 'A gaping void, yawning gulf, chasm, or abyss'.[12] That is its first incarnation: in time, for the ancient Greeks, it came to mean the primordial substance from whence the world emerged.[13] Hesiod, one of the earliest known ancient Greek poets, wrote in his *Theogony* (the birth of the Gods) that 'at the first Chaos came to be', that is, the world was born, in the words of one, from the 'empty space in-between'.[14] The Oxford English Dictionary records this definitional movement with its second entry, articulating chaos as 'The 'formless void' of primordial matter, the 'great deep' or 'abyss' out of which the cosmos or order of the universe was evolved.'[15] As a scholar Hesiod proclaims, in reference to the importance of the 'mythological imagination', that 'to be named is to proceed from nonexistence to existence'.[16] This rich vein continues, and indeed evolves, through the cosmological narrative set forth in Plato's *Timaeus*, his treatise on the natural state of the world. Plato's dialogue 'describes the creation of the world by God - not a God who creates *ex nihilo* but a "craftsman" God who creates order out of chaos'.[17] This differs from the Christian God who does creates *ex nihilo* but there is still a sense of chaos in the early Greek sense when it states in *Genesis* that 'the earth was without form, and void; and darkness was upon the face of the deep.'[18] However, for the ancient Greeks the beginning, derived from their understanding of chaos, is steeped more in metaphor than a literal concept.

---

[11] John Bussanich, 'A Theoretical Interpretation of Hesiod's Chaos', *Classical Philology*, vol. 78, no. 3, 1983, p. 213.

[12] Oxford English Dictionary, online at: http://dictionary.oed.com/cgi/entry/50036694?single=1&query_type=word&queryword=Chaos&first=1&max_to_show=10, (accessed 10/02/2007).

[13] Karl-Heinz Becker and Michael Dörfler, *Dynamical Systems and Fractals: Computer Graphics Experiments in Pascal*, trans. Ian Stewart, Cambridge University Press, Cambridge, 1989, p. 237.

[14] David Roochnik, *Retrieving the Ancients: An Introduction to Greek Philosophy*, Blackwell Publishing, Malden, 2004, p. 14. See also Sardar and Abrams, *Introducing Chaos*, p. 3.

[15] Oxford English Dictionary, online, (accessed 10/02/2007).

[16] Bussanich, 'A Theoretical Interpretation of Hesiod's Chaos', p. 214. 'The root sense of Chaos as a yawning space provides a foundation for a theoretical definition of Chaos. It should be emphasized first that as a mythical symbol Chaos must be interpreted qualitatively, not quantitatively. It should not be equated with empirical space or void. "Since its function is cosmogonic, Chaos must be defined as undimensional or principal space, an articulated nothing: it is the barest indication that there is a qualitative something, from and in which cosmic differentiation occurs."' ibid.

[17] Andrew S. Mason, 'Plato on Necessity and Chaos', Philosophical Studies, vol. 127, no. 2, 2006, p. 283.

[18] Genesis 1 [1-2], *Holy Bible*, vol. 1, King James ed., Oxford University Press, Oxford, 1895. [1611]. See also Young, 'Isaac Newton's Alchemical Notes in the Royal Society', p. 29. The reading of Genesis and *Timaeus* as somehow related is not uncommon see Jaroslav Pelikan, *What has Athens to do with Jerusalem?: Timaeus and Genesis in Counterpoint*, University of Michigan Press, Ann Arbor, 1997.

More than anything else it represents the introduction of a geometrical understanding of the world with the deliverance of order[19] (bound very much with the human fixation on establishing binaries). Travelling through time the concept of chaos has come to mean the counterweight, the opposite to order. Hobbes, who recognised a Greek god of Chaos,[20] argues that order is not only achieved (in this instance through adherence, and the manner in which it is adhered to) but is bound by both Christian doctrine and a (preferably Christian) sovereign. To ignore or to pursue a path that places Christian men beyond a sovereign, not least a Christian sovereign acting as 'God's prophet', is to face the consequences of the demise into a state that Hobbes refers to as 'first chaos'.[21] To quote Hobbes at length:

> For when Christian men take not their Christian sovereign for God's prophet, they must either take their own dreams for the prophecy they mean to be governed by, and the tumour of their own hearts for the Spirit of God; or they must suffer themselves to be lead by some strange prince, or by some of their fellow subjects that can bewitch them by slander of the government into rebellion, without other miracle to confirm their calling than sometimes an extraordinary success and impunity; and by this means destroying all laws, both divine and human, reduce all order, government, and society to the first chaos of violence and civil war.[22]

Developed here is the embedding and canonisation of order over chaos as part of the Western imagination. It becomes culturally significant to move away from chaos; civilisation is perceived to be found in order. Much has been made of such a metaphysical layering of what it is and is not to live in a 'civilised' society. In this

[19] Aryeh Finkelberg, 'Plato's Method in Timaeus', *The American Journal of Philology*, vol. 117, no. 3. 1996, p. 405. Indeed, linearity itself can be seen as perfect, eternal and to exist independently, being an example of the *Ideas* that 'are perfectly the natures they are while their instances show it forth imperfectly; they are unchangingly what they are while their instances change their participation continually; they are apprehended by pure intellection (Nous or Mind) while their instances are apprehended by the senses. The senses cannot present them, but they can in their imperfect fashion suggest them to the thinking mind.' J. N. Findlay, 'Notes on Plato's Timaeus', *The Philosophical Forum*, vol. 38, no. 2, 2007, p. 159.

[20] The terms also became personified 'By some of the Greeks Chaos was made the most ancient of the gods', Oxford English Dictionary, online, (accessed 10/02/2007). Hobbes noted that for the Greeks 'The unformed matter of the world was a god by the name of Chaos.' Hobbes, *Leviathan*, pt. 1, ch. xii, p. 173.

[21] Hobbes, *Leviathan*, pt 3, ch. , xxxvi, p. 469.

[22] ibid.

respect the Newtonian scientific paradigm can be said to have fed into this insecurity. Science, with the ability to understand the world around through mathematical abstractions, has contributed to the technological advancement of society. This progress and certainty has encouraged accompanying notions of superiority, that either shuns or urges the banishment of 'chaos'. The unpredictable and unregulated world, where all has not been classified and given its place, is to be avoided.

Chaos is not a concept peculiar to the West. Eastern creationist mythologies place a high degree of importance upon a concept that lies in opposition to order. Chinese Taoist interpretations of chaos (*Hun-tun*) are centred on the ancient notion of (or birth of) Yin and Yang (sharing a similarity to the Adam and Eve type of creationist story[23]), in which balance is achieved between the world of chaos and that of order.[24] Popular blends of Taoism, Confucianism and Buddhism enshrined chaos as a mythological beginning point. In one example, 'The First Division of Chaos', it is recorded that 'Before the beginning there was no heaven or earth, no sun or moon, no men, animals or plants.'[25] The Chinese interpretation looks, however, toward a sense of balance, as opposed to a movement away from chaos – the impact upon the cultural psyche is fundamentally different. Similarly, the Hindu-Buddhist notion of the *mandala* continues to influence across South and Southeast Asia (even in predominately Islamic states).[26] The *mandala* is a circular figure symbolising the universe where power is concentrated in the centre. The imagery, geometrical in its design, has coloured the cultural imagination, with

---

[23] 'The Eternal Mother gave birth to *Yin* and *Yang*, and to two children, male and female. She named the male child Fu-hsi and the girl Nii-kua. Fu-hsi was named Li, Nii-kua was named Chang. They were the original ancestors of man. They married. . . .After the end of primeval chaos (*hunyiian liao*),they gave birth to ninety-six *i* [9,600,000] of sons and daughters from the imperial womb (*huang-t'ai*).' Overmyer, 'Folk-Buddhist Religion:', p. 59.

[24] Sardar and Abrams, *Introducing Chaos*, p. 4. For greater detail see David C. Yu, 'The Creation Myth and Its Symbolism in Classical Taoism', *Philosophy East and West*, vol. 31, no. 4, 1981, pp. 479-500.

[25] Daniel L. Overmyer, 'Folk-Buddhist Religion: Creation and Eschatology in Medieval China', *History of Religions*, vol. 12, no. 1, 1972, p. 59.

[26] See Benedict Anderson, *Language and Power: Exploring Political Cultures in Indonesia*, Cornell University Press, Ithaca and London, 1990, esp. pp. 43-4.

power, and consequently order, focussed in the centre, with it weakening, and chaos ensuing, towards the peripheries.[27]

NOTE:
This figure is included on page 94 of the print copy of the thesis held in the University of Adelaide Library.

Figure 2: White Tara Mandala[28]

Depicted above, the mandala, in one of its many permutations, uncannily resembles the fractal images of chaos science, as described later in the chapter,[29] with its influence as a means of interpreting power, a central preoccupation in the study of international relations discussed in Chapter Four. Yet ultimately it is a visual representation of how chaos, the world of unpredictability and disorder, resides in the imagination. Purging, balancing or keeping it at bay, depending on the cultural and mythological interpretation, is a central preoccupation of human societies.[30] Order, understandably, is desired. One need only consider Hobbes's

---

[27] See Damien Kingsbury, *The Politics of Indonesia*, Oxford University Press, Melbourne, 1998, p. 24.
[28] Dharampala Thangka Centre, School of Thangka Painting, http://www2.bremen.de/info/nepal/Table1.htm, accessed, 12/08/07.
[29] Indeed, a quick search of the Internet will quickly reveal a burgeoning number of 'fractal mandala' artists.
[30] Brian Arthur, for one, feels that chaos 'is not at all new to Eastern philosophy. It's never seen the world as anything but a complex system. But it's a worldview that, decade by decade, is becoming more important in the West – both in science and in culture at large. What is happening is that we are beginning to lose our innocence, our naïveté', Sardar and Abrams, *Introducing Chaos,* p. 167. Indeed, it is felt that the so-called 'new science recognises some fundamental elements of Eastern Philosophy that rationalist science set aside as myths'. Gunaratne continues stetting out some examples which 'include holism (part-whole interdetermination), irreversibility, self-organization, and uncertainty. *Holism* is related to the Chinese philosophical concept of *Taiji* (Supreme Ultimate), the totality to which everything belongs and the source from which everything springs forth; and to the Hindu philosophical concept of *Brahman*, the oneness and interconnectedness of things. … The Buddhist concept of co-dependent arising (*paticca samuppada*) also asserts the system-environment interdependence. *Irreversibility* is implicit in the Buddhist concept of impermanence (*anicca*), which means that only evolution is possible', Shelton A. Gunaratne, 'Thank you

doomsayer warnings should anarchy prevail in which 'the life of man' would be 'solitary, poore, nasty, brutish, and short'.[31] The 'truthfulness' or accuracy of the Hobbesian position is less important than its absorption into the imagination. It is argued that the purging of 'chaos', in the general sense (that of its Greek root) and by the Western Scientific Revolution was successful. Order, built upon the Newtonian paradigm, created the impression that holistic interpretations of the world were essentially poverty-stricken. Worse still, the ordered and the linear became the good, while the chaotic and the non-linear were bad and to be expunged. The sentiment was reason ought rule in this, the ordered and rational realm, whereas imagination, supposedly spurred on by the irrational, was of the chaotic underworld, and something therefore to be shunned.

On Imagination

The Enlightenment was depicted in the previous chapter as surging through the Western world, redefining and recasting how intellectual exploration was undertaken. Newton was shown to be the focus for what came before and that which followed. Nonetheless it is helpful to consider that establishing a dominant worldview is, in part, a myth-making exercise. Not of gods and monsters, but of metaphors and analogies; how knowledge is regulated and imagined. Conversely, it was also argued that it is important to recognise that this period should not be thought of as a singular story; the Enlightenment (and the Scientific Revolution) should not be looked upon retrospectively as an era when all of the eminent intellectuals of the period were placed under a Newtonian spell from which none awoke. Before Newton, Vico was far from convinced; Hume respectfully stepped back from reason as an *a priori* function that could be distilled and separated from the human condition; Kant can be said to have never properly swallowed the Newtonian 'pill'. Later, a range of thinkers (Johann Gottfried Herder for example) can be seen to have unsettled the preferred narrative.[32] It was the 'religion' of

Newton, Welcome Prigogine: 'Unthinking' Old Paradigms and Embracing New Directions. Part 2: The Pragmatics', *Communications*, vol. 29, no. 2, 2004, p. 126.

[31] Hobbes, *Leviathan*, pt. I, ch. xiii, p. 186. This is expanded upon in Chapter Four.

[32] See, for example, Berlin, *The Proper Study of Mankind*, passim.

reason (linking in with the concept of paradigms being a belief), reduced and harnessed, which manifested in its supposed ability to control the external world that brought the ire of those who sought to separate themselves from the movement. From the Romantics and the counter-Enlightenment thinkers (inasmuch as they can be separated and delineated) came a discomfort towards mechanical and clockwork explanations. For those of such mettle, the world that arose from these abstractions did not capture the essence of what it was to be human and, from that, what is was to live with others in a community. Blake depicted Newton, naked and as part of nature, something ignored in the cold abstractions of his reasoning. Blake effectively acknowledged that which was thought to 'be' by many of his contemporaries was founded upon the opinions of Newton and, from that, upon the thoughts of Bacon and Locke.[33] The divisions between reason, rationality and reality needed, for many, to be readjusted.

The Spanish painter and printmaker Francisco José de Goya y Lucientes captured an essence in the tortured images found in many of his works of the social beyond reason and the lustre of the Age of Enlightenment, where, however, a sense of chaos could be said to lurk. His etching and self-portrait *The Sleep of Reason Produces Monsters* (*El Sueño de la Razon Produce Monstruos*) depicts that inability to separate and distil reason in any pure sense. The artist, slumped over his desk (representing the rational world) has succumbed to the sleep, and with the sleep has come the dreams that are not bound by the rationalism of the Enlightenment. The intent of Goya may be interpreted as depicting the irrational as being as much a part of the mind as any impression that the 'rational' conceives. Effectively, Goya imagines the 'nonrational possibilities of experience', and with that comes the recognition that, although 'produced', they are a part of reality.[34]

---

[33] Blake, *Annotations to Sir Joshua Reynolds* in Eitner, *Neoclassicism and Romanticism* p. 125.

[34] Paul Ilie, 'Goya's Teratology and the Critique of Reason', *Eighteenth-Century Studies*, vol. 18, no. 1, 1984, p.38. Links are easily made with Wendt who argues in establishing his social constructivism that 'We want what we want because of how we think about it' and, most importantly, that 'Desires are no less desires for being constituted by beliefs'. Wendt, *Social Theory of International Politics*, pp. 119, 125. For further elaboration see Chapter Five.

NOTE:
This figure is included on page 97 of the print copy of the thesis held in the University of Adelaide Library.

Figure 3: Francisco Goya's *The Sleep of Reason Produces Monsters*, 1803[35]

This runs counter to the principles of the Enlightenment,[36] for if reason escapes control of the enlightened man[37] then the task of purging the darkness has been 'betrayed', for no more is he 'the regulator of his mind' and, instead, 'he becomes the minister of its monsters'.[38] This is representative of the fundamental issue at stake with the dominant Newtonian paradigm, and an issue captured insightfully by one Goya scholar, when he suggested that 'reason is asleep when the imaginations deserts it'.[39] For the social or IR theorist the 'monsters' found within 'dreams' can be said to represent the ideas, values, and norms that derive from the cultural imagination (whereas for Hobbes, for example, imagination represents the

---

[35] Francisco José de Goya y Lucientes, *The Sleep of Reason Produces Monsters (El Sueño de la Razon Produce Monstruos)*, Plate 43 of *Los Caprichos*, second edition, ca. 1803, Herbert F. Johnson Museum of Art, Cornell University, http://www.museum.cornell.edu/HFJ/handbook/hb128.html, accessed 25/03/2006.
[36] Hence Goya is sometimes considered to be a part of the eclectic (and somewhat after the fact) counter-Enlightenment movement.
[37] With gendered language used quite deliberately
[38] Ilie, 'Goya's Teratology and the Critique of Reason', p. 54.
[39] Alexander Nehamas, 'The Sleep of Reason Produces Monsters', *Representations*, no. 74, 2001, p. 38.

'decay of Sense'[40]). Of course, many different interpretations are possible, but what Goya exposes is the limitations of the rationalism of the Enlightenment, not in its astonishing successes, but in its fixation on the rational individual as the axiomatic base for society and the consequent attempts to cast an ordered, singular and real vision of the world-at-large.

However, with the dawning of the twentieth century, inroads were being made in respect to appreciating the significance and importance of elements that stood outside the purely rational with respect to how humans imagine the world around them. Psychoanalysis can be appreciated as one of the earlier fields (still, at that stage, working within the dominant paradigm) that looked towards more interpretive methods. Habermas unquestionably recognised this when he drew on linkages between psychoanalysis and social theory so as to bolster his attempt to reconcile hermeneutics and natural science.[41] Sigmund Freud, when drawing upon the work of poet, philosopher and dramatist Friedrich Schiller, had a sense of the depth beyond such a rational ideal of the individual. When expanding upon how creation of art is not bound by reason, Freud called upon Schiller's 1788 letter, written in reply to a friend who was experiencing difficulty in producing literary output. In it Schiller explains that:

> The ground for your complaint seems to me to lie in the constraint imposed by your reason upon your imagination. I will make my idea more concrete by a simile. It seems a bad thing and detrimental to the creative work of the mind if Reason makes too close an examination of the ideas as they come pouring in – at the very gateway, as it were. Looked at in isolation, a thought may seem very trivial or very fantastic; but it may be made important by another thought that comes after it, and, in conjunction with other thoughts that may seem equally absurd, it may turn out to form a most effective link. Reason cannot form any opinion upon all this unless it retains the thought long enough to look at it in connection with the others. On the other hand, where there is a creative mind, Reason – so it seems to me – relaxes its watch upon the gates, and the ideas rush in pell-

40 Hobbes, *Leviathan*, pt. 1, ch. ii, p. 88.
41 Giddens, 'Jürgen Habermas', p. 126.

> mell, and only then does it look them through and examine them in mass. – You critics, or whatever else you may call yourselves, are ashamed or frightened of the momentary and transient extravagances which are to be found in all truly creative minds and whose longer or shorter duration distinguishes the thinking artist from the dreamer. You complain of your unfruitfulness because you reject too soon and discriminate too severely.[42]

Art is an emergent phenomenon that cannot be reduced or unscrambled. With this much in mind, it can be said to share similarities with a non-linear understanding of the world. Using art as a preamble to introducing chaos is not a case of presenting as an explanation of *what it is*, but as an acknowledgment that the world, when utilising the lessons from chaos, is not reducible to its brush strokes, or the canvass that is painted upon.[43] For example, Schiller's influential friend and co-collaborator,[44] the scientist and poet Goethe, whose life traversed the eighteenth and nineteenth centuries, rejected the reductionism of Newton. He was of the opinion that the pulling apart of what is to be studied in order to find a universal principle defies a holistic logic. For Goethe, to tear the petals from the flower so that its essence may be revealed removes any hope of understanding, as a flower without petals is a flower no more.[45]

---

[42] Sigmund Freud, *The Interpretation of Dreams*, 3rd (rev. English) ed., James Strachey, trans and ed., George Allen and Unwin, London, 1954 [1931], p. 103.

[43] Henri Bergson, in his *Creative Evolution*, captured a similar sentiment when we wrote: 'An artist of genius has painted a figure on his canvas. We can imitate his picture with many-coloured squares of mosaic. And we shall reproduce the curves and shades of the model so much better as our squares are smaller, more numerous and more varied in tone. But an infinity of elements infinitely small, presenting an infinity of shades, would be necessary to obtain the exact equivalent of the figure which the artist has conceived as a simple thing, which he has wished to transport as a whole to the canvas, and which is the more complete the more it strikes us as the projection of an indivisible intuition.' Henri Bergson, *Creative Evolution*, trans. Arthur Mitchell, Macmillan, London, 1911, p. 95. See also Prigogine and Stengers, *Order Out of Chaos*, p. 174. Of mechanistic theory making Bergson also observes that 'whatever form this theory may take, supposing it avails at all to explain the detail of the parts, it throws no light on their correlation' Bergson, *Creative Evolution*, p. 88.

[44] Robert Gray, *Goethe: A Critical Introduction*, Cambridge University Press, Cambridge, 1967, pp. 15-17.

[45] West and Deering, *Lure of Modern Science*, p. 5. It is important to recognise Goethe as a man of his times. Whilst working toward more holistic understandings of the world he remained drawn to the prospect of laws guiding physical and social affairs. His novel, *Elective Affinities*, sought to explain relationships of attraction (i.e. marriage) through the metaphor of chemical reactions (at the time understood via the theory of elective affinities). Yet even here it is the interactions that inform the whole that are important – beliefs and needs inform each other. Max Weber took to this notion of elective affinities the realm of sociology as means to understanding selective processes within society. See Johann Wolfgang von Goethe, *Elective Affinities : a Novel*, Trans. James Anthony Froude and R. Dillon Boylan, Ungar Publishing New York, 1962 [1809] and John T. Jost, Christopher M. Federico and Jaime L. Napier, 'Political Ideology: Its Structure, Functions, and Elective Affinities', *Annual Review of Psychology*, vol. 60, 2009, p. 308. This notion of chemical affinities, which was popular in the early eighteenth century, allowed for the creation of 'an anti-mechanistic

This sentiment can be contrasted against the earlier thoughts of Descartes that were presented in the preceding chapter. While Descartes did not completely dismiss the role of reason in the world of dreams, the full expanse of his much-quoted tract of only ever being convinced of the truth by recourse to reason displays all the hallmarks of whittling the importance of imagination, when he contends that:

> it is rather easy to know that the dreams we imagine while asleep should in no way make us doubt about the truths of thoughts we have while awake … After all, whether we are awake or asleep, we should never allow ourselves to be convinced of anything except by the evidence of our reason; and it should be noted that I say 'our reason', and not 'our imagination' or 'our senses'. Although we see the sun very clearly, we should not for that reason judge that it is only as large as it seems; and we could easily imagine distinctively a lion's head attached to a goat's body without, for that reason, thinking that there is a chimera in the world, because reason does not tell us what we see or imagine in this way is true. It tells us instead that all our ideas or notions must have some basis in truth, for otherwise it would be impossible for God, who is absolutely perfect and true, to put them in us. Since our reasoning is not as evident or complete while we are asleep as when we are awake, although what we imagine while asleep is sometimes as vivid and explicit, or even more so, reason also tells us that our thoughts cannot all be true, since we are not absolutely perfect, and that whatever truth our ideas posses should infallibly be found in those we have while awake rather than in our dreams.[46]

physiology' which confronted Newtonian ideas. Elkana, 'Newtonianism in the Eighteenth Century', p. 300. Further, Goethe recognised the wholes are composed of interrelated parts that are in constant flux and motion. See John G. Benjafield, 'Revisiting Wittgenstein on Köhler and Gestalt Psychology', *Journal of the History of the Behavioral Sciences*, vol. 44, no. 2, 2008, p. 103.

[46] Descartes, *Discourse on Method*, Part IV, pp. 27-28 He also writes in his *Meditations on First Philosophy*, complicating the issue, that he was moved to the observation that there are clearly 'no conclusive indications by which waking life can be distinguished from sleep that I am quite astonished, and my astonishment is such that it is almost able to convince me that I am sleeping', Descartes quoted in Walter Soffer, 'Descartes Rejection of the Aristotelian Soul', in Georges J. D. Moyal, ed., *René Descartes: Critical Assessments*, vol. 3, Routledge, New York, 1991, p. 200. Yet it is equally important to recognise that this is a phenomenological observation. See Crispin Wright, 'Scepticism and Dreaming: Imploding the Demon', *Mind*, vol. 100, no. 1, 1991, pp. 90-3.

For Descartes, reason allowed a clarity that was not subjectified by either the fallibility of the senses or the illusory nature of the imagination. Yet in purging the darkness and the superstition that came before, the very elements that allow for a more complete conception of how societies emerge, form and function can be said to have been sacrificed. Cultural and sociological understandings rely on accommodating the richness of interactions, and consequently they cannot be considered wholly through a reductionist agenda built upon the rationality of the Newtonian paradigm. But movements in science, via the persistent rise of anomalies, was giving credence to new ways of understanding (or beliefs about) the world, and with such advance came new ways of conceiving an understanding of the social.

The Challenge of the Non-Linear

From little things big things are said to grow; a simple idea, yet it captures both holistic and reductionist understandings of the world. The question that has been posed by the gradual development of the non-linear sciences is whether or not the big things can be understood by closely examining the little things as separate entities from which the additive results can be aggregated in a linear progression to illuminate the exact nature of the whole. This *is* the Newtonian paradigm; it is linear, it reduces, and it is closed. At its very core the scientific reductionism it imbues holds 'that anything in the material world can be reduced to particle motion', and from this linear intellectual fountain has spouted the simple and mechanistic understandings used to describe much of what occurs in the world.[47] The Newtonian worldview, as was laid out in the first chapter, and best represented by the 'Laplace Demon', has generated notions of equivalency between determinism and predictability.[48] Reductionist and linear scientific advances have allowed mankind, for example, to understand, extract and control energy, so as to support modern and technologically advanced societies. Yet there exists a failure to comprehend the sheer 'complexity of ecological systems'. As a

[47] Mikulecky, Donald C., "The Emergence of Complexity: Science Coming of Age or Growing Old?", *Computers and Chemistry*, vol. 25, 2001 p. 343.
[48] Peitgen, et al, *Chaos and Fractals*, p. 12.

consequence, it is easily argued that by not accepting the inherent holism that underpins the world's ecology, the world is being drawn to the brink of an environmental catastrophe.[49] So the paradox is evident, in that the prevailing paradigm explains a great deal and has facilitated great advances, technological achievements, and, arguably, increased living standards (at least for those in the West and a handful of newly-industrialised countries in the East). Yet it is the same worldview that reduces a complex world to basic building blocks, atomising knowledge, and is devoid (in extreme cases) of the contingency of any such 'particle'. Denied in human affairs is the constitutive nature of aggregates.[50] The actual involvement of each part upon the evolution and make-up of that whole, and that of the whole upon the part, is simply not given sufficient credence. In wanting to examine the flower as a whole, the gradual development of non-linear approaches began to 'empower' a new level of understanding, or, at the very least, there lay a questioning of the dominant paradigm. The very notion of order was attracting scrutiny. How was science to explain those phenomena that did not fit neatly into the prescribed and mathematically derived principles that were thought to explain all that lay around? Chaos and complexity were simply not neat, and proved difficult to reduce.

At its most *simple* level of explanation, of which more will follow in the next chapter, it is argued that a complex system cannot be divided into a series of non-interacting parts in the hope of divining an understanding of the system as a whole.[51] In a situation in which a complex system is divided in order to seek greater understanding, what is divided, because of centrality of interactions, quickly become 'decomposed elements'.[52] Understanding and appreciating the

[49] West and Deering, *Lure of Modern Science*, p. 2. It is beyond the scope to step into an extended climate-change debate, however, the important point is that it is only in recent decades that the interconnectedness of environmental factors has resulted in mainstreaming ecological studies. The process is representative of real world change in respect to how problems should be *reasonably* approached. Reason, it would appear, is contingent and influenced by the science of the day. See Ronald D. Brunner, 'A Paradigm for Practice', *Policy Sciences*, vol. 39, no. 2, 2006, pp. 135-67.
[50] See the work of Wendt and Rosenau in Chapter Four and the section on aggregating the state in Chapter Five.
[51] West and Deering, *Lure of Modern Science*, p. 14.
[52] ibid., p. 23.

whole is diminished because the parts are no longer a useful representation of their function when removed not just from their context but from the environment that sustains them. Philip Anderson, when chaos theory was still in its infancy, took it further, noting that the law-making of traditional linear science was becoming increasingly irrelevant as:

> The ability to reduce everything to simple fundamental laws does not imply the ability to start from these laws and reconstruct the universe. In fact, the more the elementary particle physicists tell us about the nature of fundamental laws, the less relevance they seem to have to the rest of science, much less society.[53]

The problem is that physics, in the classical sense, has been so successful that it has resulted in the unintended consequences of limiting how researchers look at the very nature of the world they seek to explain.[54] The 'monsters' continued to be pushed aside, suppressed, and the scientific imagination continued to propagate linearity and order. Unseating a paradigm, as stressed in the previous chapter, is difficult, as adherents of a particular way of understanding do not easily relinquish it. In many respects the change can be, or needs to be, generational. Yet, to push the Kuhnian line further, it becomes easier to argue, on what has already been put forth, that reductionism as an axiomatic base across entire academic spectrums is more often a case of 'wishful thinking rather than a program with established successes'.[55] Consequently:

> We seem therefore to be forced to retreat to a position according to which there are many levels of complexity, each with their own laws and concepts, and without clear and general reduction relations between them. In other words, the intuition behind the notion of reduction, namely that the deeper levels determine the

[53] Philip Anderson quoted from a 1972 article in Aubin and Dalmedico, 'History of Dynamical Systems', p. 48.
[54] Pool, 'Chaos Theory:', p. 26.
[55] Dennis Dieks and Henk W. de Regt, 'Reduction and Understanding', *Foundations of Science*, vol. 1, 1998, p. 46.

> higher ones, seems to be of a metaphysical rather than of a scientific and empirically testable nature.[56]

The process of reduction in itself becomes confused. It increasingly transforms into a self-fulfilling mantra, like Newton's planetary motions (with its reliance on God to iron out the 'kinks'); it becomes *ad hoc*, justifying the need for caveats, tying itself into metaphysical knots so as to maintain its magisterial position as the dominant (and correct) way to order and understand the world. The anomalies were beginning to come to bear; the linear and reductionist paradigm was beginning to strain, as a result of new advances towards the end of the nineteenth century. This, of course, marks the beginning of the development of what are considered to be the 'modern' (some argue it is a post-modern science[57]) non-linear sciences, and, as Kuhn argues, when the way in which the world is viewed and understood changes, then the world itself can be said to have undergone change.[58]

As has already has been discussed, Newton was not without criticism, his greatest contemporary critic, Gottfried Leibniz, dismissed the *Principia* as 'metatheoretically impossible', predominately for what became known as the three-body problem.[59] And it was this very problem that was to act as a very slow catalyst for the growth of non-linear approaches. The three-body problem has been touted 'as the most celebrated of all dynamical problems',[60] and it and the difficulty in finding a suitable solution can be put simply:

---

[56] ibid., p.47.

[57] For an illustrative example see Paul Cilliers, *Complexity and Postmodernism*, Routledge, London & New York, 1998. It is important to not that Cilliers rejects any suggestion that 'anything goes' in a post modern science. ibid., p. 115. See also, for a rejection of complexity as a post-modern science (discussed further in Chapter Five): David Byrne, 'Complexity, Configuration and Cases', *Theory, Culture & Society*, vol. 22, no. 5, 2005, pp. 97-8.

[58] Kuhn, *Structure of Scientific Revolutions*, p. 111.

[59] Toulmin, 'The Idol of Stability', p. 329. Even as early as 1747 the likes of Leonhard Euler, Alexis Clairaut and Jean le Rond d'Amberlet, in respect to the motion of the moon, thought Newton to be wrong. Prigogine and Stengers, *Order Out of Chaos*, p. 65.

[60] June Barrow-Green, *Poincaré and the Three Body Problem*, American Mathematical Society and London Mathematical Society, Providence and London, 1997, p. 7.

> Three particles move in space under their mutual gravitational attraction; given their initial conditions, determine their subsequent motion. Like many mathematical problems, the simplicity of its statement belies the complexity of its solution. For although the one and two body problems can be solved in closed form by means of elementary functions, the three body problem is a complicated nonlinear problem, and no similar type of solution exists.[61]

The difficulty in attempting to solve the three-body problem surfaces, when, in order to make the calculations, one of the three bodies is assumed to be still. This quite obviously does not occur in reality: planets keep moving, and thus over many iterations a divergence in expected outcomes becomes an uncomfortable reality.[62] The first to properly explore this area, and note its unpredictability, was the Frenchman Henri Poincaré. It was in many respects Poincaré who laid the foundation for the development of what was to become chaos theory.[63] Wider research into the field can be said to have begun in 1890 with the publication of his findings on the three-body problem (for a competition run by the King of Sweden and Norway).[64] Its findings became the cornerstone of the study of dynamical systems and, by extension, chaos.[65] It is the precursor to the now fabled butterfly effect and all that follows (see next chapter). It states that:

> If we knew exactly the laws of nature and the situation of the universe at the initial moment, we could predict exactly the situation of that same universe at a succeeding moment. But even if it were the case that the natural laws had no longer any secret for us, we could still only know the initial situation approximately. If that enabled us to predict the succeeding situation with the same approximation, that is all we require, and we should say that the phenomenon had been predicted, that it is

[61] ibid.
[62] John Gribbin, *Deep Simplicity: Chaos, Complexity and the Emergence of Life*, Penguin Books, London, 2004, p. 14. With the three-body problem cam the realisation that 'Nature as an evolving, interacting multiplicity thus resisted its reduction to a timeless and universal scheme', Prigogine and Stengers, *Order Out of Chaos*, pp. 72-3.
[63] Toulmin, 'The Idol of Stability', p. 335.
[64] Peitgen, et al, *Chaos and Fractals*, p. 508. For some they are resolute: 'Chaos was discovered by Poincaré'. Diacu and Holmes quoted in David Aubin and Amy Dahan Dalmedico, 'Writing the History of Dynamical Systems and Chaos: Longue Dureé and Revolution, Disciplines and Cultures', *Historia Mathmatica*, vol. 29, 2002, p. 9.
[65] Aubin and Dalmedico, 'History of Dynamical Systems', p. 7.

> governed by laws. But it is not always so; it may happen that small differences in the initial conditions produce very great ones in the final phenomena. A small error in the former will produce an enormous error in the latter. Prediction becomes impossible, and we have the fortuitous phenomenon.[66]

In attempting to work out the three-body problem, he was surprised to uncover that it was divergence – that is, instability – that was normal, and 'that permanently stable orbits are the exception'.[67] Further, he found with 'his new geometric approach' that although periodic orbits occurred,[68] if even the tiniest deviation in trajectory resulted away from the previous point then the behaviour that the system follows can be completely different. It was from this work that Poincaré had the realisation that two systems in near identical states can diverge rapidly, should the initial conditions differ.[69] From this chaos was born.

Laplace's demon was undermined, yet Poincaré's work, whilst not forgotten, did not have an impact upon the canon of scientific thought to the extent that observers today may have expected.[70] This is despite the fact that the Newtonian paradigm came under additional pressure in the early twentieth century by developments in Einsteinian relativity theory, and by the major advances in the realm of quantum mechanics.[71] Kuhn was well aware of these phenomena. Moreover, he understood that Newtonian dynamics was, in many respects, flawed

[66] Quoted in Gell-Man, *Quark and the Jaguar*, p. 26. See also Gribbin, *Deep Simplicity*, p. 49.
[67] Gribben, *Deep Simplicity*, p. 47.
[68] This means that approximate trajectories repeated within the phase space.
[69] ibid., pp. 47-8. See also Shermer, 'Exorcising Laplace's Demon', p. 62.
[70] Aubin and Dalmedico devote a good deal of effort to refuting the notion that Poincaré's was 'forgotten' by the sciences. The idea that the varied branches of mathematics differs epistemologically depending on which scientific discipline acquires it is solid but the attempt to suggest that irrespective of differences between the varied domains that the transfer of ideas '*could nevertheless take place*' beggars belief in that the very notion of a paradigm shift immediately complicates communication. Aubin and Dalmedico, 'History of Dynamical Systems', pp. 5, 24.
[71] Relativity theory, both general and special, undermined the Newtonian worldview by challenging absolute notions of space and time. Albert Einstein is central to the development of the field. See John Stachel, 'History of Relativity' in Laurie M. Brown, Abraham Pais and A. B. Pippard, eds, *Twentieth Century Physics*, vol. 1 American Institute of Physics Press, Salem, 1995, pp. 249-57. At the other end of the spectrum, quantum mechanics deals with sub-atomic particles and highlighted some of the difficulties in classic kinetic theory. Thinkers like Max Plank and Werner Heisenberg were central to its development. Helmut Rechenberg, 'Quanta and Quantum Mechanics' in ibid., pp. 143-6. Moreover, quantum mechanics revealed indeterminacy at this sub-atomic level, comprising attempts at prediction. Trigg, *Rationality and Science*, p. 189. See also Jeans, *Physics and Philosophy*, ch. 5 and 6.

and that the work of Einstein had formally displaced Newton's world. Yet, as Kuhn noted, the Newtonian perspective remained dominant. In essence, the equations that descended from the *Principia* still provided excellent approximations for much that is undertaken by engineers, and even in the work of some physicists.[72] Yet quantum mechanics, supporting Poincaré's earlier conclusion, undeniably unsettled Laplace's demon. Before the onset of the Second World War, Nobel Laureate Werner Heisenberg developed his uncertainty principle, which encapsulates the idea that:

> In the strict formulation of the causality law – 'when we know the present precisely, we can calculate the future' – it is not the final clause, but rather the premise, that is false. We cannot know the present in all its determining details.[73]

Significantly, it holds that the 'more precisely the position is determined, the less precisely the momentum is known in this instant, and vice versa'.[74] Uncertainty was imposing itself upon the known scientific world. The implications for the social sciences are still yet to be seen but as complexity theorist Stuart Kauffman puts it:

> Eighteenth-century science, following the Newtonian revolution, has been characterized as developing the sciences of organized simplicity, nineteenth-century science, via statistical mechanics, as focusing on disorganized complexity, and twentieth- and twenty-first-century science as confronting organized complexity.[75]

The Heisenberg principle has led to the introduction of the simple idea that 'localization becomes blurred' as at '[each] instant the position of the object will

---

[72] Kuhn, *Structure of Scientific Revolutions*, pp. 98-99.
[73] Peitgen, et al, *Chaos and Fractals*, p. 12. See also Harvey David L., and Reed, Michael H., 'Social Science as the Study of Complex Systems' in Kiel, L. Douglas and Elliot, Euel, eds, Chaos Theory in the Social Sciences: Foundations and Applications, University of Michigan Press, Ann Arbor, 1996; Immanuel Wallerstein, *Unthinking Social Science: The Limits of Nineteenth Century Paradigms*, 2nd Edition, Temple University Press, Philadelphia, 2001, p. 34.
[74] Cristian S. Calude and Michael A. Stay, 'From Heisenberg to Gödel via Chaitin', *International Journal of Theoretical Physics*, vol. 46, no. 8, 2007, p. 2013.
[75] Kauffman quoted in Mathews, et al., 'Why Study the Complexity Sciences', p. 454.

become arbitrarily distant'.[76] Essentially, what is precluded by quantum theory is the 'detailed prediction of molecular phenomena,'[77] which supports the realization that at all levels of reality there lies an 'essential element of conceptualization'.[78] The uncertainty inherent in reason was now being advocated by sciences, bringing it into line what many a poet, artist and painter had long contended. After a slow start, interrupted by two world wars and a long recovery, the *science* of chaos began its reach both into the scientific and popular imagination.

Chaos: The Rise of Uncertainty

In 1997, the Oxford English Dictionary added a further definition to its entry under chaos, which reads as follows:

> **chaos**, *n.*
> Add: **[3.] c.** *Math.* Behaviour of a system which is governed by deterministic laws but is so unpredictable as to appear random, owing to its extreme sensitivity to changes in parameters or its dependence on a large number of independent variables; a state characterized by such behaviour.[79]

The science of chaos, so named after a paper by Tien Li and James Yorke,[80] became a part of the English lexicon as a theory that looked at randomness, in supposed opposition to the ordered Newtonian world. The American Mathematical Society dedicated its annual symposium in the late 1980s to the exploration of chaos and fractals. Importantly, its focus was upon the 'realization that even the simplest of dynamical systems may behave extremely unpredictably'.[81] Indeed, unpredictability is the phenomenon that best describes chaotic systems. Understanding both the chaotic and the complex lies in recognising the transition

[76] Prigogine and Stengers, *Order Out of Chaos*, p. 224
[77] Kauffman, *At Home in the Universe*, p. 23.
[78] Prigogine and Stengers, *Order Out of Chaos*, p. 226.
[79] Oxford English Dictionary, URL, accessed 10/02/07. It should also be noted that the definition should refer to dynamical systems which, are those systems that change over time. They can either be described as dissipative, in that they lose energy (i.e. due to friction) or they are conservative, meaning that there is no loss of energy.' Sangit Chatterjee and Mustafa R. Yilmaz, 'Chaos, Fractals and Statistics', *Statistical Science*, vol. 7, no. 2, 1992, p. 50.
[80] See Tien-Yien Li and James A. Yorke, 'Period Three Implies Chaos', *The American Mathematical Monthly*, vol. 82, no. 10, 1975, pp. 985-92.
[81] Robert L. Devaney, 'Dynamics of Simple Maps' in Robert L. Devaney and Linda Keen, eds, *Chaos and Fractals: The Mathematics Behind the Computer Graphics*, *Proceedings of Symposia in Applied Mathematics*, vol. 39, American Mathematical Society, Providence, 1989, p. 1.

point between predictability (the notion of 'harmony') to unpredictability (the pre-science notion of chaos).[82] The antagonism between order and chaos within the sciences has been viewed as a significant division. Chaos was where things broke down. If laws, simple or the complex, failed to adequately explain the world, then chaos ensued. But this was not a recognition of a 'higher' or different form of order or normalcy, it merely represented the failure of nature to obey certain laws under certain conditions.[83] This is reminiscent of Kuhn's concept of the paradigm defence, as more often than not a failure to adequately explain could be, or was, blamed on the inability of the researcher, a failure of the equipment or some other level of incompetence, or a lack of an appropriate research program. Previously, such views were expressed in the following way:

> In combination with the indisputable successes of modern science over the past 200 years it has lead to a disastrous misconception: that everything is computable. When today a model fails and predicted events do not occur, we simply assume that the model was not good enough, and that is why the predictions fail. We confidently believe that this can be corrected by more and better measurements and bigger mathematical and computational investment.[84]

The emergence of chaos theory thus resulted in planting seeds of doubt, undermining principles that science could unlock the 'computability of the world'.[85] Before the end of the 1980s, chaos theory was being marched into the Parthenon of scientific breakthroughs to rival the discoveries of relativity and quantum physics earlier in the century. It was a new paradigm that finally put an end to clockwork determinism, liberating scientists from strict linear parameters and allowing new and novel ways to describe the 'incomprehensible randomness' in the world around.[86] The excitement soon found its way into the social sciences and the humanities, with some demanding the social and natural sciences to be

[82] Becker and Dörfler, *Dynamical Systems and Fractals*, p. 5.
[83] Peitgen, et al, *Chaos and Fractals*, p. 585.
[84] Becker and Dörfler, *Dynamical Systems and Fractals*, p. 237.
[85] ibid., p. 233.
[86] Gunaratne, ' Thank you Newton, Welcome Prigogine', pp. 113-14.

unified under the one banner of 'dissipative structures'.[87] One historian declared that the Western world was entering a phase that was akin to the intellectual upheaval that took place during the Enlightenment, and that ultimately resulted in the modern worldview.[88] However, for some objectors the rapid elevation of chaos theory represented a 'swing of the pendulum' that 'generated new excesses'.[89] In many respects, however, it is the language of chaos that has been truly successful in these areas: 'the simplicity and power of the ideas involved, the striking terminology', strange attractors, butterfly effects, fractals and indeed the word 'chaos' itself struck a chord in the popular imagination.[90] Further, it became a 'visual theory', with fractals and, in particular, the Mandelbrot set (which is covered in the next section) becoming the 'public emblem for chaos'.[91] Its use has become propagated across many different fields. In the social sciences its greatest impact has been as a scientific metaphor that trades on concepts and images so as to 'illuminate, illustrate, or motivate a new way of thinking' within a particular field. In this respect, such an approach towards qualitative research is 'merely suggestive' and assists more as a 'literary device'.[92] Gleick enthusiastically recounts one renowned physicist who developed, in the excitement of the rapid exploration of chaos and the inability for some to recognise a paradigm shift, a penchant for quoting Tolstoy, in particular Tolstoy's castigation that he knew:

[87] ibid., p. 115. The term 'dissipative structure' was coined by Prigogine and Stengers. See *Order Out of Chaos*, p. 12. Harvey and Reed offer the following definition: 'Dissipative systems are natural thermodynamic entities capable of evolutionary behavior. Two characteristics set dissipative systems off from other natural entities: First, they have the capacity to import energy from their immediate environment and transform that energy into increasingly more complex, internal structuration. By dint of their ability to increase metabolically their structural and functional complexity over time, we can say that dissipative systems are "information accumulating" and "information preserving" configurations. Second, although all thermodynamically ordered systems naturally accumulate increasing levels of random disorder, dissipative systems have the capacity to offset this tendency toward organizational decay by transporting their internal disorder out to their environment.', Harvey and Reed, 'The Evolution of Dissipative Social Systems', pp. 377-8

[88] Alan Beyerchen quoted in Paul A. Roth and Thomas A. Ryckman, 'Chaos, Clio, and Scientific Illusions of Understanding', *History and Theory*, vol. 34, no. 1, p. 31.

[89] Aubin and Dalmedico, 'History of Dynamical Systems', p. 3.

[90] Drawing on Ruelle in Aubin and Dalmedico, 'History of Dynamical Systems', p. 54.

[91] Gleick, *Chaos*, p. 221.

[92] Stephen H. Kellert, 'Extrascientific Uses of Physics: The Case of Nonlinear Dynamics and Legal Theory, *Philosophy of Science*, vol. 68 no. 3, Supplement: Proceedings of the 2000 Biennial Meeting of the Philosophy of Science Association. Part 1: Contributed Papers, 2001, pp. S457-8.

> that most men, including those at ease with those of the greatest complexity, can seldom accept even the simplest and most obvious truth if it be such as would oblige them to admit falsity of conclusions which they have delighted in explaining to colleagues, which they have proudly taught to others, and which they have woven, thread by thread, into the fabric of their lives.[93]

Kuhn's thesis of paradigm shifts weaves through such disclosures. A paradigm will be defended with enormous energy even when confronted by evidence that undermines it. However, it is important to remember that scientists, and by extension other researchers, should not surrender to each and every new whim, and chaos theory's rapid ascendancy (after a long gestation) was a cause for concern as it did have a strong populist element attached to it. The question that needed answering was whether non-linear science offered no more than a metaphor for moving away from Newtonian interpretation or did it represent a true metaphysical shift that offered an element of scientific pedigree, that is, a genuine paradigm. This is where supporters of chaos theory push, often implicitly, the importance of paradigms, by advocating and accepting that the 'chaos' within much of what is studied in the physical world has meant that an increasing number of scientists are beginning to appreciate certain anomalous behaviour as 'normal'.[94]

A step back from the publicity and the drive that accompanied that advent of chaos theory in the 1970s and 1980s is necessary. All too easily it is forgotten that despite the popular attention that chaos theory received in the mid- to late-1980s, and the accompanying claims of a scientific revolution, its development had in fact begun a little earlier.[95] As the 'chaos' juggernaut quickened its pace, it was increasingly noted that a great deal that was being presented as new had already been extensively worked and published by Poincaré. Many mathematicians at the

---

93 Gleick, *Chaos*, p. 38. Always dramatic, Gleick earnestly make his point in respect to the early chaos researchers 'they accept risk to their careers. A few freethinkers working alone, unable to explain where they are heading, afraid even to tell their colleagues what they are doing – that romantic image lies at the heart of Kuhn's scheme, and it has occurred in real life, time and time again, in the exploration of chaos.' ibid. p. 37.
94 Becker and Dörfler, *Dynamical Systems and Fractals*, p. 237.
95 As has been noted earlier with the 1890 work of Poincaré.

time reacted to this oversight, doing their utmost to highlight that the foundations of the so-called scientific revolution was built upon the theory of dynamical systems founded by Poincaré in the previous century.[96] For some, historiographically, the name 'chaos theory' signifies an acceptance of the viewpoint that its rapid ascent in the 1970s represented a rupture, whilst to use the name 'dynamical systems' is indicative of an acceptance of the continuity of ideas from the past. Notions of paradigm shifts stir, as it illustrates that the rise and popularisation of chaos theory during that period should also be appreciated as 'a vast process of sociodisciplinary convergence and conceptual reconfiguration'.[97] Importantly, this should not deny that 'the science of nonlinear phenomena has a prehistory',[98] and such a notion is rich in the historicist tradition of which Kuhn is intrinsically a part. The science was re-shaping the imagination and providing, in time, the social sciences with attractive analogies with attractive 'scientific' foundations. Yet what was it that made a system chaotic, what were the analogies that were rapidly discovering transference beyond their original academic bounds?

The definition at the beginning of this section lays it out reasonably succinctly: first and foremost it must be a system. When looking at a system, it is the many elements that make it up and it is the manner in which these elements affect each other that is important. Systems will nearly always fit several criteria. They will be dynamic in that lasting change can be effected upon them. They will also have multiple parameters, making them complex. And finally, they will be iterative. The last point means that they are very much influenced by the concept of feedback, detailed in the next chapter.[99] Completely describing how such a system interacts is impossible. Instead, the focus should be on investigating the regularities 'that form the basis of such dynamical systems'.[100] In addition to this, 'chaotic' systems will always be sensitive to initial conditions, meaning that a

[96] Aubin and Dalmedico, 'History of Dynamical Systems', p. 1, passim.
[97] ibid. p. 3
[98] ibid. p. 4.
[99] Becker and Dörfler, *Dynamical Systems and Fractals*, p. 5.
[100] ibid.

simple causality principle will not always hold. Basically, the proportionality between cause and effect disappears, with the consequence of the 'computability' of the behaviour of the system deteriorating over the longer term.[101] Because of chaos, the predictability of a non-linear dynamical system 'sooner or later breaks down'.[102]

In amongst this, it needs to be remembered that chaos ultimately presents a paradox as it still remains deterministic. This means that the underlying rules that drive chaotic systems do not change. In principle, this suggests that the future is very much determined by the past. Of course, small uncertainties emerge, indicating that concrete predictability quickly dissipates over longer time-frames.[103] In short, chaos can be defined as deterministic randomness.[104] Described as a whole, this means that deterministic chaos is 'aperiodic bounded dynamics in a deterministic system with sensitive dependence on initial conditions'.[105] Aperiodic means that no given state within the system is ever repeated, bounded by the fact that irrespective of the number of iterations the system cannot expand beyond its finite range. Deterministic means that the 'temporal dynamics and spatial interactions are regulated by defined rules'. Finally, sensitivity to initial conditions refers to the divergence that occurs between systems over time that begin from near identical starting points.[106]

Sensitivity to initial conditions is one of most important elements when examining chaos. As it is a notion that has not merely transferred but underscores how complex systems are understood, a longer explanation is undertaken in the following chapter. But the remainder of this chapter focuses on what became chaos theory's great adventure, as it became immersed in the world of fractal

[101] ibid., p. 238.
[102] Peitgen, et al, *Chaos and Fractals*, p. 52.
[103] ibid., p. 11. Chaos theory, for some, provided 'a mechanism that allows for free will within a world governed by deterministic laws'. Crutchfield et al (1989 48-9) quoted in Aubin and Dalmedico, 'History of Dynamical Systems', p. 2.
[104] Robert Pool, 'Chaos Theory: How Big an Advance?', *Science*, vol. 245, no. 4913, 1989, p. 26.
[105] Kaplan and Glass quoted in Mathews, et al., 'Why Study the Complexity Sciences', p. 445.
[106] ibid., pp. 445-6.

imagery. For the mathematicians who first began to study chaos, the images on their computer screens presented an opportunity to show the world the beauty of the mathematics that would normally only reside in the mathematicians' minds. For the mathematicians and for those who admired the art of fractals, the images were beautiful because their form and shape replicated many shapes to be found in the natural world.[107] Nature appeared to be born out chaos, mirroring an earlier Greek root, as an acorn is to an oak tree.

Fractals

The development of the computer in the twentieth century (ironically, very much imagined in the linear tradition) presented mathematics with an experimental apparatus[108] that allowed an unprecedented access into the mind of the mathematician. Further to this, the rapid advance and accessibility of personal computers has allowed non-mathematicians to consider the usefulness of non-linear modelling and phenomena to their research.[109] As for the impact on those specifically studying chaos, the computer has been used to produce novel and new ways to model and generate results, making it, arguably, a necessary and compulsory apparatus for those wishing to study in the field.[110] This has been made no more apparent than in the realm of fractals, as it is the visual representation generated by computers that define them. The saying that a picture is worth a thousand words immediately comes to mind. The visualisation should not be understated, as again the notion of the importance of the whole quickly emerges from any such appreciation. Gleick noted, in his popular text, that some mathematicians who embraced the graphic images that derived from chaos felt that to deny the rise of the graphic representations offered by computers was a form of 'masochism' that stymied a mathematician's ability to recognise potential relationships, and, thereby, in the process retarding an intuitive understanding.[111]

[107] Ian Stewart, 'Portrait of Chaos' in Nina Hall, ed., *The New Scientist Guide to Chaos*, Penguin Books, London, 1991, p. 44.
[108] Becker and Dörfler, *Dynamical Systems and Fractals*, p. 2.
[109] Bruce and Deering, *Lure of Modern Science*, p. 2.
[110] Aubin and Dalmedico, 'History of Dynamical Systems', p. 28.
[111] Gleick, *Chaos*, pp. 38-9.

However, when discussing fractals, the father of the movement, Benoit Mandelbrot, can hardly be ignored. Not a traditional academic, he traversed many fields, from economics, linguistics and communication networks through to more traditional disciplines like mathematics, physics and the medical sciences.[112] Mandelbrot has made it clear that he did not approach the development of fractals with a master plan in mind. For him, the process involved drawing on his eclectic, some have said 'nomadic', experiences that have always been conducted via a scientific and geometric lens.[113] His research was, in his own words, concentrated on developing 'systematically a nascent geometry of roughness'[114] that better explained the world, both social and natural, around him. The computer offered him the opportunity via its ability to compute over multiple iterations and to produce the aforementioned visual representation, which he, as its discoverer, named. In doing so, he coined the term 'fractal' derived from the Latin adjective *fractus*, meaning rough and broken up, and the corresponding verb *frangere*, meaning to break. The words 'fragmented' and 'fraction', deliciously for Mandelbrot, also derive from these roots.[115] But more so the word was invented to also:

> bring together under one heading a large class of objects that have certain structural features … [and to show] … the historical role that fractals played in the development of pure mathematics. A great revolution of ideas separates the classical mathematics of the 19th century from the modern mathematics of the 20th century. Classical mathematics has its roots in the regular geometric structures of Euclid and the continuously evolving dynamics of Newton. … Historically the revolution was forced by mathematical structures that did not fit the patterns of Euclid and Newton. These new structures were regarded as

[112] Peitgen, et al, *Chaos and Fractals*, p. 64.
[113] ibid.
[114] Benoit B. Mandelbrot, 'Selected Topics in Mathematics, Physics and Finance Originating in Fractal Geometry', in Miroslav M. Novak, ed., *Thinking in Patterns: Fractals and Related Phenomena in Nature*, World Scientific, New Jersey, 2004
[115] Mandelbrot, 'Selected Topics', p. 2 and Mandelbrot, *Fractal Geometry*, p. 3. Mandelbrot has also stated elsewhere that when coining the phrase in his mind something that could, over time, come to mean 'rough but self-similar', Benoit B. Mandelbrot, 'Fractals and the Rebirth of Iteration Theory', in Peitgen and Richter, *The Beauty of Fractals,* p. 157.

> pathological, as a gallery of monsters, kin to the cubist painting and atonal music that was upsetting established standards of taste in the arts about the same time. The mathematicians who created the monsters regarded them as important in showing that the world of pure mathematics contains a richness of possibilities going far beyond the simple structures they saw in nature. Twentieth-century mathematics flowered in the belief it had transcended completely the limitations imposed by its own origin.[116]

The monsters here are the anomalies to which Kuhn refers. Yet these fractal 'monsters' are more than just eye-catching computer-generated images. It is how simple underlying rules can generate images of incredible depth and sophistication that captures the imagination. To explain this, one could observe that 'fractals are geometric shapes that are equally complex in their details as in their overall form'.[117] This means that when a portion of a fractal is magnified in the appropriate area, it will bear a striking resemblance to the whole.[118] This sameness between the macro and micro is called self-similarity and the relationship between scale, and the predictability and regularity of form, defines the fractal phenomenon.[119] When speaking of fractal geometry, it is the archaic notion of geometry, that of 'concrete actual images', that is being evoked.[120] Visualising the results allows for conclusions to be drawn about the underlying mathematics,[121] and in doing so fractals assist in helping to allow the observer to visualise, understand and reimagine the concept of limits through the lens of self-similarity.[122] Perhaps the most recognisable of fractals is that which was

---

[116] Freeman Dyson, 'Characterizing Irregularity', *Science*, vol. 200, no. 4342, 1978, p. 677-8. See also Carl Bovil, *Fractal Geometry in Architecture and Design*, Birkhäuser, Boston, 1996, pp. 17-18.

[117] Benoit B. Mandelbrot, 'Fractals and an Art for the Sake of Science', *Leonardo: Computer Art in Context Supplemental Issue*, no. 2, 1989, pp. 21-2.

[118] ibid., Indeed, '[r]oughly speaking, self-similarity means that a set remains qualitatively similar in its spatial characteristics under contraction or magnification', in Chatterjee and Yilmaz, 'Chaos, Fractals and Statistics', p. 53. But, importantly, 'no part of the [Mandelbrot] set exactly resembles any other part, at any magnification', Gleick, *Chaos*, p. 228.

[119] Robert Constanza, 'A vision of the Future of Science: Reintegrating the Study of Humans and the rest of Nature', *Futures*, vol. 35, 2003, p. 659.

[120] Mandelbrot, 'Fractal Geometry: What is it', p. 8.

[121] Becker and Dörfler, *Dynamical Systems and Fractals*, p. 3. Indeed, as an aside when noting that fractal structures occur daily in the world around us Becker and Dörfler, in 1989, felt that as computing and associated technologies improved that it would not be long before films incorporated 'lengthy sequences calculated by a computer'. ibid. pp. 211-12.

[122] Peitgen, et al, *Chaos and Fractals*, p. 137.

developed and named after Mandelbrot, with the full set (as they are referred to) in figure 3, and figure 4 showing the near infinite depth when the fractal is zoomed in on:

Figure 4 (*right*): The Mandelbrot Set.[123]

NOTE:
This figure is included on page 117 of the print copy of the thesis held in the University of Adelaide Library.

NOTE:
This figure is included on page 117 of the print copy of the thesis held in the University of Adelaide Library.

Figure 5 (*left*): Zoom – 'Large Cleft between major bulb and first minor'.[124]

For Mandelbrot, before the arrival of fractals, mathematicians had fled the patterns of nature and instead devised 'theories unrelated to anything we can see or feel'.[125] In part, this occurred because drawing has stopped playing a role in mathematics 'because hand and pencil and ruler were exhausted'.[126] Mandelbrot felt that the return of visualising results, through (and because of) computer-generated images, returned a level of intuition to mathematics.[127] For him, the irregularity and fragmentation that is to be witnessed in the world of nature runs contrary to the smooth lines of Euclidean geometry. This is most evident when one considers that a structure that is seen through a Euclidean lens becomes

[123] Mandelbrot Pictures, http://www.chem.vu.nl/~feenstra/mandel_gallery.html, (accessed 13/10/2007).
[124] ibid.
[125] Mandelbrot, *The Fractal Geometry of Nature*, p. 1.
[126] Gleick, *Chaos*, p. 102.
[127] ibid.

increasingly simple as the scale is reduced.[128] Further, the geometry of old was 'cold' and 'dry' and could do little to explain or, more importantly, describe the shapes found in the natural world.[129] A cloud cannot be described by spheres alone, the ruggedness of a mountain is not a perfect cone and lightning does not travel in straight lines.[130] A much-quoted tract that epitomised the almost immediate public appeal of such an approach was made by Michael Barnsley:

> Fractal geometry will make you see everything differently. There is a danger in reading further. You risk the loss of your childhood visions of clouds, forests, galaxies, leaves, feathers, flowers, rocks, mountains, torrents of water, carpets, bricks, and much else besides. Never again will your interpretations of these things be quite the same.[131]

It is conceivable, then, that within the natural world, space filling structures are organised and form in a manner similar to fractal geometry.[132] The difficultly in wanting to utilise fractal geometry is that it does not have a 'clean definition' and for all intents and purposes, and probably for the better, it is not a 'self-contained' body of work.[133] Kenneth Falconer is of the belief that any definition of a fractal should bear resemblance to how biologists may attempt to define life. That is, that there is no singular hardened definition, but more a list of properties that define something as being alive.[134] Freeman Dyson continues:

> Now, as Mandelbrot points out, nature has played a joke on the mathematicians. The 19th century mathematicians may have been lacking in imagination, but nature was not. The same pathological structures that mathematician invented to break loose from 19th century naturalism turn out to be inherent in familiar objects all around us.[135]

[128] Peters, *Fractal Market Analysis*, p. 4.
[129] Mandelbrot, *Fractal Geometry*, p. 1.
[130] ibid.
[131] Michael Barnsley, *Fractals Everywhere*, Academic Press, San Diego, 1988, p. 1.
[132] Peitgen, et al, *Chaos and Fractals*, p. 94.
[133] Mandelbrot, 'Fractal Geometry: What is it', p. 9.
[134] Kenneth Falconer, *Fractal Geometry: Mathematical Foundations and Applications*, 2nd ed., Wiley, Chichester, 2003, p. xxvv.
[135] Dyson, 'Characterizing Irregularity', p. 678. See also Bovil, *Fractal Geometry in Architecture*, p. 18.

It is not difficult to look at the natural world and to recognise some element of self-similarity from galaxies down to trees.[136] At the very least, 'chaos' is no less common in the world-at-large than the simple behaviour espoused by a traditional scientific outlook.[137] Using the example of trees, a fractal understanding pays credence to the notion that there exists an idea as to what a tree looks like.[138] Figure 5 illustrates that with only twenty-eight numbers and a few simple underlying rules, a computer can produce a fractal image that bears an amazing resemblance to a fern leaf one might stumble upon in the natural world.

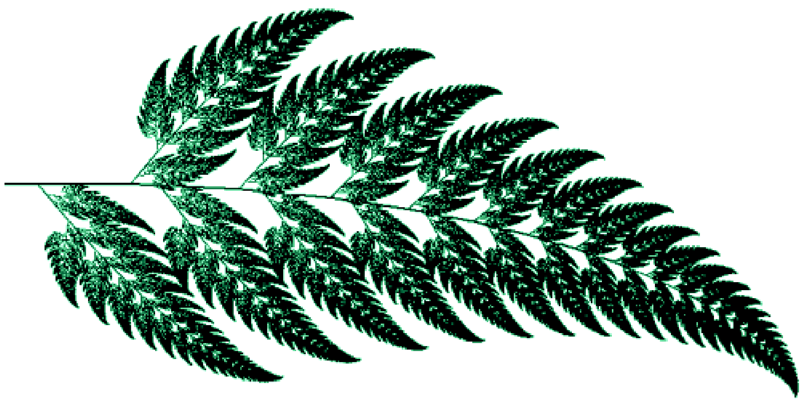

Figure 6: Self-Similar Fern Fractal[139]

Generating fractals of this nature is dependent upon the application of transformation upon spaces; the novelty occurs because the application is simple yet the results geometrically complex. Further, these are the very conditions that both manifest and are defined at the parameters.[140] To give a brief description: a fractal set can be said to contain an infinite number of points whose very organisation is complicated to such a degree that it is simply an impossibility to

---

136 Bovil, *Fractal Geometry in Architecture*, p. 3.

137 Jack Cohen and Ian Stewart, *The Collapse of Chaos: Discovering Simplicity in a Complex World*, Penguin Books, London, 1994, p. 190.

138 Peters, *Fractal Market Analysis*, p. 4.

139 Chaos and Fractals, 'Iterated Function Systems', http://www.pha.jhu.edu/~ldb/seminar/ifs.html, (accessed 13/10/2007). 'This image is infinitely complex — it is a self-similar fractal on all scales. What is truly amazing is that only 28 numbers are necessary to generate this infinitely complex image: four 2 x 2 transformation matrices, four 2 x 1 translational vectors, and four weighted probabilities for the transformations (each attractor).' ibid.

140 Barnsley, *Fractals Everywhere*, p. 2 Curiously, one chaos scholar, Linda Keen, dissected the mathematics behind the Julia Sets and, in passing, noted that they 'did not study the dependence on the parameters' which often presents as a common omission by many who have studied deterministic chaos. Kuhnian notions of incommensurability come home to roost upon such admissions. See Linda Keen, 'Julia Sets' in Devaney and Keen, eds, *Chaos and Fractals*, p. 58.

explain the nature of the set by describing, in an exactitude, where each point lies. If a description is required it is better explained in terms of the relationships between the points.[141] An important point that should not be neglected by social scientists, for the IR specialist it emphasises the relational component between agents in any given system or society. Importantly, Mandelbrot acknowledges that the study of fractals do not represent a panacea.[142] However, perhaps the two most important elements to be drawn from Mandelbrot's work are that, first, a complicated image is produced via multiple iterations from simple underlying rules,[143] and, secondly, that a chaos and fractal-based understanding deals with local randomness but has global determinism.[144] This determinism, however, becomes problematic when attempting to reconcile the metaphysical impact upon any analysis of the social realm. This is discussed at greater length below, but the idea that fractals capture an element of a differing belief structure is the defining point.

Returning to the previous point and to relate the generation of fractals to trees (as opposed to ferns), it is apparent when venturing through a forest (or perhaps for the ease of the analogy, a plantation of trees of the same species) that a level of self-similarity does exist but ultimately every tree is different.[145] It is therefore less so a case of not seeing the trees for the wood, or the wood for the trees, but more a case of recognising that the whole is made up by similar, yet ultimately unique, entities. Evidently the same can be said of ferns, so by extension it is possible to conclude that there are no true naturally occurring fractals; much in the same sense that there are no true naturally occurring circles or straight lines.[146] It must be remembered that real-world fractals are finite, meaning one can only magnify and look at the detail before the concept breaks down,[147] and the self-similarity

[141] Barnsley, *Fractals Everywhere*, p. 5.
[142] Mandelbrot, *Fractal Geometry*, p. 3.
[143] Gribbin, *Deep Simplicity*, p. 97.
[144] Peters, *Fractal Market Analysis*, p. 5.
[145] ibid., p. 4.
[146] Falconer, *Fractal Geometry*, p. xxvi.
[147] Peitgen, et al, *Chaos and Fractals*, p. 105. Although Mandelbrot contends that nature can *almost* be scaled to an infinite level. Mandelbrot, *Fractal Geometry*, p. 1.

involves 'some random variations on a basic theme'.[148] It is also important to remember that when generating the computer images for fractal sets, these cannot escape the fact that they are still only approximations. The Mandelbrot set is only accurate to within 10 per cent. A computer-generated image of a magnified area that mathematically is no larger than a hydrogen atom cannot possibly be a 'true' or 'pure' representation, if only because of the errors from rounding off or the shortcomings of the graphic interface.[149] This reminds the observer that a fractal interpretation is one of *roughness*. When looking at the resolution of a fractal, with greater magnification comes greater data or 'descriptive information' about the patterns that become available at the higher resolutions but accurate modelling becomes increasingly difficult.[150] Following from this is an assertion that perhaps the Mandelbrot set is only a 'shadow',[151] which arguably can be said to turn the Platonist worldview on its head. Chaos becomes the world of the Demiurge:

> To describe our physical world they created a geometry based on pure, symmetric and smooth forms. Plato said that the 'real' world consisted of these shapes. These forms were created by the 'Good'. The world of the Good could only be glimpsed occasionally, through the mind. The world we inhabit is an imperfect copy of the real world, and was created by a different entity called the 'Demiurge'. The Demiurge, a lesser being than the Good, was doomed to create inferior copies of the real world. These copies were rough, asymmetric and subject to decay. In this way Plato reconciled the inability of the Greek geometry, later formalized by Euclid, to describe our world. The problem was not with geometry, but with our world itself. … Fractal geometry is the geometry of the Demiurge. Unlike Euclidean geometry it thrives on roughness and asymmetry. Objects are not variations on a few perfect symmetrical forms, but are infinitely complex. The more closely they are examined the more detail is revealed.[152]

[148] Bovil, *Fractal Geometry in Architecture*, pp. 9-10.
[149] Constanza, 'A vision of the Future of Science', p. 660. This is reminiscent of the claim attributed to John von Neumann's that 'Truth is much too complicated to allow anything but approximations', Cochrane, 'Virtual Mathematics', p. 275.
[150] ibid.
[151] John Ewing, 'Can we see the Mandelbrot Set?', *The College Mathematics Journal*, vol. 26, no. 2, 1995, p. 99.
[152] Peters, *Fractal Market Analysis*, p. 3.

Such a fuzziness or roughness, as to what is certain similarly transfers to the fourth dimension – except in death, time did not escape Newton. The very notion of time has been unable to escape linear determinism. Creationist to Big Bang theorists have presented an arrow of time from 'chaos' through to order.[153] Indeed, theoretically, Newtonian time was considered reversible until notions drawing on thermodynamics illustrated the irreversibility of time. Fate, destiny, providence are built unconsciously upon linear and deterministic conceptions of time,[154] with Newton's laws allowing Laplace and others 'to describe a completely deterministic world in which both past and future are rigidly fixed and there is no scope for free will'.[155] Yet notions of self-similarity can be used to explain how development of particular technologies or the generation of similar ideas have emerged at the same time.[156] It is difficult to 'escape' time-based linear determinism, human existence from life to death being defined by it. Written and spoken language and communication are predominately built upon it, meaning that the brain, although intricately networked in a non-linear manner, favours ordering that is linear in nature. Historical processes and causality are two such examples. Visual communication is far less limited by linear progressions and hierarchical models. Connections that loop and feed-back, draw on different interpretations. Essentially, drawing on a network of ideas and experiences occurs a good deal more freely with visual communication. Difficulty in describing such connections freely is, in part, linked to our linear understanding of time, life and language.[157]

Fractals and chaos brought an appreciation of the rough, of the broken and of the visual; something the abstractions of mathematics had eroded into almost non-existence. The notion of a fractal understanding had in many respects *re-entered* the imagination, but did so by entering the popular scientific imagination. The

---

[153] Ilya Prigogine, 'The Arrow of Time' in V. G. Gurzadyem and R. Ruffini, eds, *The Chaotic Universe*, Advance Series in Astrophysics and Cosmology, vol. 10, World Scientific Publications, Singapore, 2000.
[154] Peters, *Fractal Market Analysis*, pp. 5-6. See also Wallerstein, *Unthinking Social Science*, p. 33.
[155] Gribbin, *Deep Simplicity*, p. 18.
[156] Peters, *Fractal Market Analysis*, p. 6.
[157] Herbert W. Franke, 'Refractions of Science into Art', in Peitgen and Richter, *The Beauty of Fractals,* p. 183.

ideas, as is so often the case, were not necessarily new, and Mandelbrot, in his eclectic manner, drew on the work of fifteenth century theologian and philosopher Nicholas of Cusa, whose notion of 'learned ignorance' attracted and piqued his interest. Mandelbrot felt that a fractal worldview exists implicitly in the latter's writings, and is encapsulated in the idea that 'wherever one is, one thinks is the center'.[158] Cusa's pre-Kepler and pre-Copernican ideas that the earth was not the centre and that the planets do not have perfect circular orbits was bound by his notion of the infinite[159] and the idea that 'the world has its center everywhere, and thus nowhere, and its circumference is nowhere'.[160] Importantly, it is not just the fractal interpretation to which Mandelbrot alludes, but it is more Cusa's own theological reckonings that, like the infinite and incomprehensible nature of God, perfect knowledge is unattainable.[161] This is not a question of belief, but a rejection of an additive world that can be understood and calculated as a finite entity. Yet again, this is an idea that has been reflected by many through the ages. Artists and artisans, especially, have appreciated fractal-like geometrics and the notion of the infinite, pre-empting many of the insights of man-the-scientist who sought only order in *his* understanding.

Fractals and Art

With the development and increased accessibility of computers the generation of fractal images has become a popular and creative means to produce visual representations of mathematics – which in turn has been presented by some as forms of art. Art of this kind, which exists (or, at least, is created) in a virtual space, has been accompanied by proclamations of a blurring of the line that has been seen to traditionally separate the worlds of art and science.[162] The very idea of art, a social construction, is never short of a definition and can be easily portrayed as a

[158] Mandelbrot, *The Fractal Geometry*, p 206.
[159] Thomas J. McFarlane, 'Nicholas of Cusa and the Infinite', *Integral Science*, March 2004, rev. ed., www.integralscience/cusa.html, accessed September 10 2006.
[160] Mandelbrot, *The Fractal Geometry*, p 206. See also James Jeans, *Physics and Philosophy*, Cambridge University Press, Cambridge, 1943, pp. 59, 107.
[161] See, for example, Frederick Charles Copleston, *A History of Philosophy: Volume III Late Medieval and Renaissance*, Continuum, New York, 2003 [1956], pp. 231-48
[162] Becker and Dörfler, *Dynamical Systems and Fractals*, pp. 3, 6-16.

creature of the Demiurge. Art allows for the interpretation of the roughness and the shadows that 'make' the world that we live in and perceive ourselves to be a part of on a day-to-day basis. On the other side of the line, in the world of science, Mandelbrot has consistently argued that fractal geometry breaks down the division, as the 'systematic and quantitative approach to the study of roughness' gives scientific credence to art and beauty.[163] Mandelbrot delights in pointing out that modern fractal art could only emerge because of the computer and that there is a 'profound irony' that these computer based models can be described as 'organic' and 'baroque'. Indeed, the irony is heightened in that it is the marrying of the mathematics and the computer, that is, 'the inhuman, the dry, and the technical' that has supported this new art form.[164] Forever the scientist, Mandelbrot speaks of the attractiveness and the usefulness of fractals being linked in a utilitarian manner. Although illustrating a limited idea of art, as art neither has to be beautiful nor possess any level of utility, his point remains solid in that both art and science 'reflect' the world. The matter is one of the dominance of paradigms, and what is thought to appropriately depict what is 'real' or what is worth knowing. In many respects it is the analytic and intuitive divide, between science and art, that is being bridged.[165] However, it is vital to recognise that 'fractal' and 'self-similar forms' in the world art, architecture and other realms of human creation predate chaos as a separate field of scientific enquiry. Yet again triumphalist conjecture that chaos theory has opened a previously unforeseen door needs to be tempered somewhat. To quote Briggs:

> When painters juxtapose multiple self-similar forms and colors on canvas, or composers transform a sequence of notes into different sections of the orchestra, they create a tension that gives birth to lucid ambiguities. Such artistic juxtapositions might be

[163] Mandelbrot, 'Selected Topics', p. 30. Controversially, he argues that a flower is beautiful to the mind, but it is this beauty that attracts the insect, and it is this notion that he relies upon to extend his belief that fractals are a mathematics of the 'real world' that can be used to explain and describe cultural elements within society. In particular, it is the 'works of Man' to which he refers, See Mandelbrot, 'Fractals and an Art', p. 22 and Mandelbrot, 'Selected Topics', p. 30. Of course, the manufacturing of beauty can easily be interpreted as an entirely social process. However, the construction of which can still be said to inhabit an orderly space that appeals to the human mind.

[164] Mandelbrot, 'Fractals and an Art', p. 22.

[165] Peitgen and Richter, *The Beauty of Fractals,* p. 1.

> called 'reflectaphors' because the self-similar forms reflect each other yet contain metaphors, a tension composed of similarities and difference between the terms. This reflectaphoric tension is so dynamic that it jars the brain into wonder, awe, perplexity, and a sense of unexpected truth or beauty.[166]

Briggs notes that fractals and notions of non-linearity are part of both an old and new aesthetic. Citing the Romantic poet John Keats's idea of 'negative capability', which suggests and that an artist's creativity is unlocked by 'uncertainties, mysteries and doubts'.[167] This is an idea that is reminiscent of the letter written by Schiller that so enamoured Freud. Here the world of dreams and interpretation are as 'real' as the hard and cold abstractions of rationality. Similarly, Briggs quotes Leonardo da Vinci as stating 'that the painter who has no doubts will achieve little' and suggested that the stains on the wall may well provide inspiration.[168] Da Vinci's work *A Deluge* (figure 7), which is far removed from Euclidean determinism, can be appreciated for containing the turbulence and scaling that can be witnessed in the chaotic phenomena associated with turbulence.[169]

NOTE:
This figure is included on page 125 of the print copy of the thesis held in the University of Adelaide Library.

Figure 7: Leonardo da Vinci, *A Deluge*, 1517.[170]

[166] Quoted in Nicoletta Sala, 'Fractal Geometry in the Arts: An Overview Across Different Cultures', in Novak, ed., *Thinking in Patterns*, , p. 187.
[167] Briggs, *Fractals: The Patterns of Chaos*, pp. 27-8.
[168] ibid.
[169] Mandelbrot, *Fractal Geometry*, plate C3. Turbulence is an idea that has been pursued by Rosenau as a powerful non-Newtonian metaphor to describe the international system. See Rosenau, *Turbulence in World Politics*, passim. This is pursued in chapters four and five.
[170] Leonardo da Vinci, *A Deluge*, 1517, one of series of ten known such sketches, 'Probably acquired by Charles II: Royal Collection by 1690', The Royal Collection: Royal Palaces, Residencies and Art Collections, www.royalcollection.org.uk, (accessed 10/05/2007).

How the world is analogised and visualised in the mind's eye is the contested ground of both art and science. Science can now be depicted as sharing paradigmatic space alongside art, permitting a greater emphasis toward interpretive methods. In Mandelbrot's own words: 'I would hold that this is exactly the point that the "roughness" of the non linear should be no surprise and that fractals allow us to acknowledge an already present admiration for the "organic"'.[171] If mathematics explains the structures that make up the real world, that is, the underlying logic, then there should be diminished surprise that the notion of beauty and the beautiful is very much tied to what we find in the natural world. Natural beauty is that to which the mind has 'evolved to find pleasing'.[172] Our very appreciation of symmetry can also be tied into human (and more generally biological) evolution. Symmetry, it has been argued, provides a rough guide to predator/prey scenarios, as it assists in distinguishing between the non-living and the living-in-a-busy-(data)-environment, and, most compellingly, symmetry forms the basis for the appreciation in the human form. Beauty is found to be symmetrical.[173] Ultimately, many of the 'forms' that are associated with fractals:

> have always been central to the creative activity of artists. They have always been central to the scientific study of the natural world. Thus an intuitive awareness of them has been a part of human civilization from the beginning.[174]

What exists is an 'unconscious fractal component to the arts'[175] that has been repeated and reflected through multiple civilizations – the mind's eye has been active in the visualisation of non-Euclidian geometrics well before the computer provided a new art form. Over centuries, fractal forms can be seen in ancient Egyptian artefacts through to arts from the Gothic and Baroque periods. Similarly,

---

171 Mandelbrot, 'Fractals and an Art', p. 21.
172 Roger Lewin, 'Mathematics at 100', *Science*, vol. 240, no. 4853, 1988, p. 721.
173 Barrow, *Impossibility*, p. 5.
174 Etienne Guyon and H. Eugene Stanley, eds, *Fractal Forms*, Elsevier Science Publishers and Palais de la Décorvete, 1991, preface.
175 Sala, 'Fractal Geometry in the Arts', p. 178.

various sub-Saharan African cultures have displayed such geometric designs, some dating back some 2000 years. Stoneworks found in Mauritian and Ghanaian sculptures can also be said to have similarities with some fractal representations.[176] Many of the geometric designs and patterns of classical Islamic art and architecture have an element of self-similarity.[177] Some of the most striking similarities, however, can be found in traditional Japanese artworks that often depict self-similarity and bifurcation processes.[178] The woodcut *Waterfall in Yoshino*, by Japanese artist Kaysushika Hokusai, is rich with fractal scaling common in traditional Asiatic art (Briggs refers to such scaling as 'reflectaphors').[179] Similarly, Hokusai's renowned painting *The Great Wave* (Figure 8) can be appreciated from a fractal and bifurcation perspective.[180] Bifurcation involves the splitting of the main body into two parts and so on and so forth – *ad infinitum*.[181] Importantly, it is understood to act as an indicator as to the 'onset' of chaos and is graphically illustrated when Hokusai's 'wave' is closely examined (and is repeatedly illustrated by a great deal of Asiatic art). Indeed, it also depicts the onset of turbulence; a critical and unpredictable tipping point in any chaotic system.

176 ibid. pp. 178-80. 'We can find it [unconscious fractal components] in the north of Mozambique, in the South of Tanzania, in the Congo/Zaire region and in Senegal,' ibid.

177 ibid., pp. 184-5. Further intricate Indian decorative works known as Kolams which adorn doorways and courtyards can be said to be of a fractal nature. Wolfram goes to considerable length to illustrate that fractal or nested form have inhabited human cultures for millennia. He gives examples of zig-zag designs on bracelets mad from mammoth ivory around 24000 years ago through to Sumerian mosaics (3000BC) Greek labyrinth designs (1200BC), Phoenician ivory carvings (900BC) Celtic mirror design (100BC) ; the rosette patterns of Roman mosaics (200AD); the Great Mosque of Córdoba (800AD); the rose window in Lincoln Cathedral (1300AD), and; Pir-i-Bakran mausoleum, Iran, with Kufi calligraphy inspired wall decorations (1400AD). Wolfram, *New Kind of* Science, pp. 873-4.

178 Sala, 'Fractal Geometry in the Arts', 180-1.

179 Briggs, *Fractals: The Patterns of Chaos*, p. 173.

180 Mandelbrot, *Fractal Geometry*, plate C16.

181 'In a dynamical system, a bifurcation is a period doubling, quadrupling, etc., that accompanies the onset of chaos. It represents the sudden appearance of a qualitatively different solution for a nonlinear system as some parameter is varied.' Weisstein, Eric W., 'Bifurcation', *MathWorld--A Wolfram Web Resource*, http://mathworld.wolfram.com/Bifurcation.html, accessed 10/12/07. In addition it is worth noting that Poincaré coined the term bifurcation 'to designate the emergence of several solutions from a given solution', James Rosenau, *Turbulence in World Politics: a Theory of Change and Continuity*, Princeton University Press, 1990, p. 58.

NOTE:
This figure is included on page 128 of the print copy of the thesis held in the University of Adelaide Library.

Figure 8: Katsushika Hokusai's *The Great Wave at Kanagawa*, ca. 1830–32[182]

To return to a Kuhnian perspective, whereby scientific thought can be depicted as 'convergent (fundamentally conservative) or divergent (fundamentally innovative')',[183] adds, like Hokusai's *Great* Wave, to the notion of bifurcation, arguably one of the great explanatory ideas (along with sensitivity to initial conditions and strange attractors) to have emerged from chaos and fractals. It denotes an irreversibility, an equilibrium shifting (in respect to positive feedback) and draws links with phase (or state) space and phase transitions.[184] Its conceptual power can be appreciated as being an intrinsic and endogenous element within non-linear dynamical systems. Moreover, the theoretically infinite depth challenges the Euclidean geometrical experiences that contained the Western imagination to clean neat straight lines and perfect circles. Indeed, Euclidean shapes can be said to be lacking textual depth[185] and are devoid of life's

[182] Katsushika Hokusai's *The Great Wave at Kanagawa* (from a Series of Thirty-six Views of Mount Fuji), Edo period (1615–1868), ca. 1830–32, The Metropolitan Museum of Art, New York, http://www.metmuseum.org/, (accessed 23/09/2007).
[183] Lugg, 'Kuhn and the Philosophy of Science', p. 292.
[184] All of which are discussed in the next chapter.
[185] Bovil, *Fractal Geometry in Architecture*, 1996, p. 3.

roughness.[186] The fractals of chaos theory redefined concepts of straight lines and simplistic notions of cause and effect' much more complex phenomena could arise from very simple beginnings. Artistically, many, as has been shown, understood this at some level.

The notion that art imitates nature is an idea that returns to ancient Greek philosophy, yet correlations between nature and music have not been so easily recognised. In *Laws, Book II* Plato asserts that, '[f]or when there are no words it is difficult to recognise the meaning of harmony and rhythm, or to see that any worthy object is imitated by them'.[187] Conversely, Richard Voss, drawing on the randomness of Brownian motion[188] that is interwoven with chaotic fractal functions, states that in actuality 'music imitates the way nature changes through time'.[189] *Scientific American* columnist Martin Gardner[190] leapt on this when he articulated that:

> It is commonplace in musical criticism to say that we enjoy music because it offers a mixture of order and surprise. How could it be otherwise? Surprise would not be surprise if there were not sufficient order for us to anticipate what is likely to come next. Good music, like a person's life or a pageant of history, is a

---

[186] Mandelbrot, 'Fractals and an Art', p. 21. An obvious example of geometric artwork that defied this tradition is that of the perennially popular Dutch graphic artist M. C. Escher. His use of geometry is well documented but his unconscious use of fractal geometry and self-similarity drew on his admiration for the geometric designs of Moorish palaces, his reading (of what he could understand) of Pólya's 1924 work (Published in *Zeitshrift für Kristallographie* – the journal of crystallography) and his lifelong friendship with renowned British mathematician H. S. M. Coexeter. Elsewhere Mandelbrot contends that Escher's tessellations 'were knowingly triggered by Poincaré' as a result of Coexter's friendship. The mathematician later commenting on Escher's *Circle Limit III* (1959) found that 'Escher's work, based on his intuition, without any computation, is perfect, even though his poetic description of it … was only approximate'. Escher himself declared that 'since a long time I am interested [sic] in patterns with "motives" getting smaller and smaller til they reach the limit of infinite smallness'. See Sala, 'Fractal Geometry in the Arts', p. 182. See also H. S. M. Coxeter, 'The Non-Euclidean Symmetry of Escher's Picture 'Circle Limit III'', *Leonardo*, vol. 12, no. 1, 1979, pp. 19-20. See also Benoit B. Mandelbrot, 'People and Events behind the "Science of Fractal Images"' in Heinz-Otto Peitgen and Dietmar Saupe, *The Science of Fractal Images*, Springer-Verlag, New York, 1988, p. 4.

[187] Bovil, *Fractal Geometry in Architecture*, pp. 103-107.

[188] Brownian motion is based, in its most classic example, of tracking the random movement of particles that have been suspended in a fluid. On the link between Brownian motion and fractals see Tom Lindstrrøm, 'Brownian Motion on Nested Fractals', *Memoirs of the American Mathematical Society*, vol. 83, no. 420, 1990, pp. 1-13.

[189] ibid.

[190] Not to mention puzzle maker and magician. On his influence and immense popularity see Elwyn Berlekamp and Tom Rodgers, eds, *The Mathemagician and Pied Puzzler: A Collection in Tribute to Martin Gardner*, A K Peters, Wellesley, 1999.

> wondrous mixture of expectation and unexpected turns. There is nothing new about this insight, but what Voss has done it to suggest a mathematical measure for this mixture.[191]

What develops, via a 'fractal awareness', is of the interconnectedness between explanations of the natural world and that of human creativity and interpretations. Objects built by humans for more functional purposes can also be thought of similarly; interesting comparisons can be made with architecture teasing out a fractal interpretation.[192] The infinite, the 'fractal', and the ultimately chaotic can be viewed as inspiring creative *and* ordered constructions – a paradox that chaos theory did not necessarily come to terms with effectively or at least persuasively. It was deterministic randomness; of the two words, the former undermined the later.

To take Jonathan Swift's quote at the beginning of the chapter, there has long been a fascination with the infinite: '[s]o Nat'ralists observe, a flea/Hath smaller fleas that on him prey,/And these have smaller yet to bite'm,/And so proceed, ad infinitum'.[193] Chaos theory recognised and embraced the uncertainty of what emerged from infinite possibilities. Fractals presented highly ordered images, easily digested by the mind, and as examples of what could emerge from these possibilities. Swift, the political satirist who presented scaling or 'reflectorphors' of a different mettle in the multiple worlds found in his *Gulliver's Travel*, satirised no less than the division of knowledge that was occurring in his own time. During this period, in which science meant the knowledge of certainty in its broadest sense, Swift regaled at the division and creation 'of the arts and sciences' as

---

[191] Bovil, *Fractal Geometry in Architecture*, p. 5.

[192] Frank Lloyd Wright, through his childhood experiences, developed a level of intimacy with the relationship between music and nature. His architecture was inspired through this organic understanding of the world. A fractal approach or understanding within architecture involves a level of scaling, either with the surrounding environment or details upon entering the building that communicates the intent of the design. Lloyd Wright is credited with using such an approach, although he did not phrase it in such terms, in which his houses would show a 'progression of detail from large to small'. Lloyd Wright's approach reflects how architecture is generally experienced, beginning with the overall profile of the building, and as the observer nears greater detail is experienced from windows and doors, right down to the doorknob. Once inside the process continues. ibid. pp. 5-6, 111, 117.

[193] Jonathan Swift quoted in Mandelbrot, *The Fractal Geometry*, p. 402. See also Gliek, *Chaos*, p. 103 and Briggs, *Fractals: The Patterns of Chaos,* p. 41.

separate entities.[194] Chaos, through fractals, can be thought of as an attempt to find a way back from that precipice.

Considering the world of the creative mind in the context of the overall thesis, whether the painter on canvas, the musician, or the architect, is not an indulgence. It is central to the argument that science is also an imaginative process that is shaped by cultural-historical factors, and, importantly, plays a constitutive role in return. Moreover, both art and natural sciences can be understood as 'first order practices', from which 'second order practices' of social science and IR theory draw from.[195] This is reflective of a diversity of thinkers, this can include Kuhn, but more so R.G. Collingwood and his idea of 'absolute presuppositions'.[196] Or, for IR theory, this is often reflected via the work of the political theorist John Gunnell.[197] Here, art, science, religion and politics (read power) are primordial and feed into the receptacle of IR theory.[198] Imagining the relationship between chaos and order is in the process of being redefined. Art, and creative expression more generally, has often sought to examine the relationship as opposed to purging it. This is quite different to what traditional science hoped to achieve. The mature and normal sciences, as imagined in Kuhn's world, were paradigmatically trapped, whilst the creative mind was framed, but not bound, to the same extent. The artist, knowingly and unknowingly, challenged boundaries of accepted thought.

Conclusion – Chaos as a Tipping Point

The ascendency of chaos theory in the 1970s and 1980s was an explosive affair. It cut across disciplinary barriers allowing scientific, social, popular and artistic imaginations to reconfigure how the world in all its complexity might be

[194] Douglas Lane Patey, 'Swift's Satire on "Science" and the Structure of Gulliver's Travels', *ELH*, vol. 58, no. 4, 1991, pp. 819, *passim*.

[195] Brian C. Schmidt, 'On the History and Historiography of International Relations' in Carlsnaes, Walter; Risse, Thomas and Simmons, Beth A., eds, *The Handbook of International Relations*, Sage, Thousand Oaks, 2002, p. 5.

[196] Jay Newman, 'Metaphysics and Absolute Presuppositions', *Man and World*, vol. 6, no. 3, 1973, pp. 290-92. On presuppositions see next chapter.

[197] Schmidt, 'On the History and Historiography of International Relations', p. 5.

[198] ibid. See also Gunnell, 'Realizing Theory, pp. 932, 936.

interpreted (and, importantly, in relation to each other, to return to the rock pool analogy). The mechanical world was apparently being undone. Of course, as has been shown, this process began much earlier. Poincaré, in the late nineteenth century, illustrated the absurdity of Newtonian dynamics once a third object was introduced to the equation. Moreover, the previous chapter outlined philosophical objections, Vico's for example, towards how the world was conceptualised. Yet in terms of creating the feel of a revolution, a new direction:

> The breakthrough came when physicists stopped looking for deterministic invariants and began looking for geometric patterns in phase space. What they found was a wholly different kind of order amidst chaos, the phenomenon of self-similarity at different geometric scales. This suggested that many phase-space portraits of dynamical systems exhibited fractal geometries; and this was taken as an indication that a wholly different approach must be taken to the description of the evolution of mechanical systems.[199]

The rather esoteric concept of phase space is discussed at length in the following chapter, but the principal idea of a breakthrough, as depicted above, brought forth, for many, the possibility of a brave new world. Indeed, its incorporation into the more 'scientific' of social sciences began with considerable fanfare. Nowhere was this more evident than in economics, a discipline that had been showing levels of fatigue in terms of its academic rigour. For some time critics had noted that the abstract and impressively constructed mathematical axioms economics did not always accurately model the 'real' world.[200] Chaos theory emerged as an exciting (and potentially profitable[201]) new tool for economic analysis. Mandelbrot did not see things terribly differently, showing some understanding towards the new theory he helped devise:

> All too many disciplines harbour the strong wish of becoming quantitative, but do not even know how to begin. One standard way is to ask new questions for known answers, that is to borrow

[199] Philip Mirowski, 'From Mandelbrot to Chaos in Economic Theory', *Southern Economic Journal*, vol. 57, no. 2, 1990, p. 300.
[200] See for example Waldrop, *Complexity*, p.170
[201] ibid. p. 212.

> procedures from disciplines that have already reached a quantitative stage, and to hold onto those procedures if they appear effective. One finds the procedures that one could borrow are not particularly numerous. While the diversity of nature seems to be without bound, the number of techniques one can use to grasp nature is extremely small and increases very rarely. Therefore the enthusiasm generated by the birth of a new technique and the desire to test it more widely is healthy and must not be disparaged.[202]

Its appeal and apparent utility similarly found followers in academic disciplines that are traditionally viewed as being some of the more 'social' of the social sciences. For example, being applied to concepts of empire, one study looking at the fractal nature that supposedly characterised the development of the Ottoman Empire.[203] Others have sought, more scientifically, to quantifiably establish the 'parameter regimes' for understanding alliance-building among states.[204] Ole Wæver saw the evolution of particular international societies as having a fractal dimension. Self-similarity occurs as a by-product of the maintenance of the system.[205] Normative considerations are fundamental to this process as they establish an '"expectation system" of self and others'.[206] The society or system (and the interchange between the two terms is important) will achieve its stability by closing 'itself from other systems'. How it forms its fractal dimension is informed by the norms that presuppose its existence. Christian norms will evoke the development of a self-similar international society, guided by particular rules and norms.[207] Differently, it has been argued that globalisation has a fractal element. In this light, globalisation is not a fixed and static process yet, there exists an idea of an overall whole. Within this amorphous concept lies the fractal dimensionality,

---

[202] Mandelbrot, 'Fractal Geometry: What is it, and What does it do?', p. 11.

[203] Güngör Gündüz, 'The Fractal Dimension of the Rise of an Empire', *The Journal of Mathematical Sociology*, vol. 24, no. 4, 2000, pp. 303-320.

[204] Alvin M. Saperstein, 'Alliance Building Versus Independent Action: A Nonlinear Modeling Approach to Comparative International Stability', *The Journal of Conflict Resolution*, vol. 36, no. 3, 1992, p. 519. Saperstein is very much the *social scientist*, attempting to measure potential outcomes. Further, he is quite accepting of realist assumptions, with his calculations based in 'a purely anarchic world'. ibid. p. 540.

[205] Ole Wæver, 'Four Meanings of International Society: A Trans-Atlantic Dialogue, in Barbara, Roberson, ed., *International Society and the Development of International Relations Theory*, rev. ed., Continuum, London, 2002, p.121,

[206] Onuf, *World of Our Making*, p. 130.

[207] Wæver, 'Four Meanings of International Society, p. 121.

sub-systems of different 'scapes' each reflecting an alternative idea of globalisation. These scapes represent different worlds within the much larger edifice of globalisation; 'ideoscapes, technoscapes, financesapes, ethnoscapes, and mediascapes',[208] all of which scale all the way down.

Chaos theory, if nothing else, had borne Gödel's child.[209] Chaos had underscored the principle that not every question that is asked of a logical system can be answered.[210] In this it was not just a scientific revolution that was thought to be occurring, but also a cultural one. To take Kuhn's central argument that science has an inherent historicism, it is indelibly irrespective of empirical research, bound by its own cultural parameters.[211] The birth of Gödel's child accompanied, gave rise to or was a result of a social process that as much reflected advances within the 'hard' sciences as it did the social upheavals and turmoil that had been occurring around them in their own time:

> Amongst mathematicians, the crisis of 1968 and the Vietnam War has given rise to a fundamental reevaluation of the nature of their profession, whose dominant cultural images were turned upside down. For the Bourbakist hegemony emphasizing the structural and axiomatic conception of pure mathematics disconnected from applications and needs of society at large – in short, mathematics 'for the honor of the human spirit' (Dieudonné 1987) – was progressively substituted for a new

[208] Melba Cuddy-Keane, Modernism, Geopolitics and Globalization', *Modernism/modernity*, vol. 10, no. 3, 2003, p. 544. This ideas of differing 'scapes' draws on the work of anthropologist Arjun Appadurai. Rosenau, similarly, draws from Appadurai. See Rosenau, 'Many Damn Things Simultaneously', p. 74. For Stäheli, Appadurai's ideas do not far enough as they maintain a hierarchy the denies the importance of how bifurcation implodes the idea of the global. Here, the micro/macro or local/global dichotomies should escape from the macro-events versus local narratives and should instead represent an appreciation of a deterritorialisation, for the former, and reterritorialisation for the latter. Urs Stäheli, 'The Outside of the Global', *The New Centennial Review*, vol. 3, no. 2, 2003, pp. 17-18. Of course, this selective process is open to the criticism of cherry-picking only those chaos metaphors that support the intended argument.

[209] Kurt Gödel was a noted logicician and close friend of Albert Einstein. His work on incompleteness theorems exposed particular logical deficiencies when calculating from axiomatic starting points. John W. Dawson, 'Gödel and the Limit of Logic', *American Scientific*, June 1999, pp. 68-73. See also Niklas Luhmann, *Social Systems*, trans. John Bednartz Jr., Stanford University Press, Stanford, [1984], 1995, p. xlviii.

[210] Pool, 'Chaos Theory:', p. 28.

[211] It is important to stress that the interplay between culture and historicism in a more general sense was first brought to the fore, in a meaningful manner for philosophers and historian, by none other than Vico. See Berlin, *Against the Current*, p. 114.

> conception of mathematics more self-conscious of its social role.[212]

The question then arises: did chaos theory contribute to a revolution? Methodologically, despite Mandelbrot protestations that the analysis of fractals lacks any 'unified tools',[213] it has allowed for 'dimension in its many forms' to be utilised as the singular most important 'tool' for looking at fractals.[214] For example, a coastline has a fractal element dependent upon the agreed unit of measurement.[215] It can be broken continuously, illustrating the infinite nature of fractal geometry. Yet this ultimately falls into the paradox that Xeno put to Aristotle, and it must remembered that a whole is always a whole before breaking it into its constituent, even if infinite, parts. Yet while theoretically infinite, fractals are bounded. The issues with chaos do not end here, most poignantly, the deterministic randomness does not allow for the analysis of complex and *adaptive* behaviour.[216] Chaos may help explain the formation of clouds and forgive meteorologists for being unable to make long-range weather forecasts[217] but its *direct* usefulness to social systems is limited. Cohen and Stewart marvel at chaos, but are critical of its misappropriation and the expectations that were placed upon it. In relation to the Mandelbrot set, they give the following cartographic example:

> It's a bit like trying to give directions to a friend who is coming to visit. You can fax her an entire map of Philadelphia; or you can send her a much shorter message: 'First road on your left after Burger King and the second on your right; park under the third streetlight and it's the house with the stupid gnome in the front

---

[212] Aubin and Dalmedico, 'History of Dynamical Systems', p. 52.
[213] Mandelbrot, 'Fractal Geometry: What is it', p. 9.
[214] Falconer, *Fractal Geometry*, p. xxii.
[215] Mandelbrot, *Fractal Geometry*, pp. 25-30. 'Fractional dimension becomes a way of measuring qualities that otherwise have no clear definition: the degree of roughness or brokenness or irregularity in an object. A twisting coastline, for example, despite its immeasurability in terms of *length*, nevertheless has a certain characteristic degree of roughness' in Gleick, *Chaos*, p. 98. See also Benoit Mandelbrot, 'Stochastic Models for the Earth's Relief, the Shape and the Fractal Dimension of the Coastlines, and the Number-Area rule for Islands', *Proceedings of the National Academy of Sciences*, vol. 72, no. 10, 1975 pp. 3825-3828. Further, this very much reflects the Koch curve, or Koch snowflake whose 'coastline' or border is infinitely long. See, for example, Gribbin, *Deep Simplicity*, pp. 92-3
[216] In international relations it is vital to recognise that behaviour can the induce change in the environment. Robert Jervis, 'Complex Systems: The Role of Interactions', in in Albert, David S. and Czerwinski, Thomas J., eds, *Complexity, Global Politics and World Affairs*, University Press of the Pacific, Honolulu, 1997, p.43.
[217] See Gaddis, 'International Relations Theory', pp 54-5.

> garden.' But for the Mandelbrot set, there's a twist: Given the second message *alone* (the rule) she can reconstruct the entire map of the town (the Mandelbrot set). There is no equally simple rule to reconstruct Philadelphia.[218]

Fractals, as a revolution, did not overturn the Newtonian paradigm. More tellingly, chaos theory in itself continued to rely upon a significant level of determinism, making claims of a new paradigm difficult. Early chaos theorists Doyne Farmer and Norman Packard moved away from the study of chaos, finding its simple-mindedness, the way in which computer-generated images blindly followed particular equations, jejune after a period. It was, in effect, lacking richness.[219] For Farmer, chaos had very little to say about adaptation, evolution and the underlying dynamics of living systems. He was interested in studying how complex wholes developed.[220] Yet, as an outcome of conceptual reconfigurations, chaos brought forth changes that are irrevocable. It has contributed significantly to the emergence of a new epistemological framework, with many of the central ideas and tenets transferring to the complexity sciences. The next chapter will make evident many of these ideas that have descended from the initial forays into chaos theory. Chaos theory, in this regard, did represent a partial revolution. Communication between the various rock pools had been facilitated in a new and novel way that allowed a fuzziness and a roughness to how the world might be interpreted. In short, chaos theory was a transition that was both ephemeral and irreversible.[221]

Yet what does chaos mean in respect to how the world is imagined? What is evident is that order and chaos are not oppositional points. They are entwined and they inform each other. Purging chaos should no longer be the concern of scientific or social theories. Understanding or learning to appreciate the anomalies as a part of the world should become accepted practice. Chaos *theory* attempted this. Its

[218] Cohen and Stewart, *Collapse of Chaos*, p. 197.
[219] Waldrop, *Complexity*, pp. 131-2.
[220] ibid, p. 287.
[221] Aubin and Dalmedico, 'History of Dynamical Systems', p. 55. For some we are still too close to the chaos moment in history to know its place in the Parthenon or graveyard of scientific ideas. ibid. p. 50.

most telling impact is the meta-theoretical implications of its absorption. For some, the theory has really only, although significantly, imposed the 'limitations of predictability'.[222] On the other hand, one of chaos theory's successes is how it has encouraged, indeed created and driven, cross-disciplinary research and communication.[223] Chaos has also blurred boundaries around traditional dichotomies, challenging epistemological constructs, ranging from the obvious order/disorder, but also notions of non-randomness, stability, the simple and the local to the corresponding ideas of randomness, instability, the complex and the global. [224] It is also the recognition that patterns, and symmetries in particular, play and important role in how the world is perceived, simplified and understood by the human mind.[225] The 'science of chaos' may not have lived up to promise and enthusiasm that accompanied its arrival. Partly, this is due to the overstatement of popular science, but more so because it only represented a beginning of the non-linear advance. Its lasting impression is certain, as is its use and abuse. Ian Stewart has sounded a warning in that:

> The term 'chaos' has escaped its original bounds, and in doing so has to some extent become devalued. To many people, it is no more than a new and trendy word for 'random'. Take some system with no obvious pattern declare, it to be an example of chaos, and suddenly it is living on the intellectual frontiers instead of being boring old statistics again. Chaos has become a metaphor, but far too often the *wrong* metaphor being extended to areas where there is no reason to expect a dynamical system, but the very implications of the metaphor are being misrepresented. Chaos is used as an excuse for the absence of order or control, rather than as a technique for establishing the existence of hidden order, or a method for a controlling a system that at first sight seems uncontrollable.[226]

In one respect, Stewart is correct in that the term chaos has become a loose metaphor that is too often applied in its scientific context with a complete lack of

[222] Gell-Man, *Quark and the Jaguar*, p. 276
[223] Aubin and Dalmedico, 'History of Dynamical Systems', p. 36.
[224] ibid., p. 53.
[225] Barrow, *Impossibility*, pp. 4-5.
[226] Sardar and Abrams, *Introducing Chaos*, p. 169.

understanding of the depth of the metaphor as it relates to a dynamical system. Conversely, Stewart, as a scientist, misses the point that within the social realm the science of chaos has allowed the imagined idea of chaos to escape from the restraints of the cool rationality of the Newtonian paradigm. Analogising the social can be approached without resorting to notions of order that are built in opposition to chaos. Indeed, order and chaos are forever entwined – how we make sense of one or the other is dependent upon a complex interlocking of scientific, social, political and cultural manifestations. Ontological and epistemological foundations deliver a privileged perspective, at present this remains Newtonian or derivates thereof. Fractally, it is possible to suggest that this privilege is replicated across multiple levels throughout society.

The challenge is to accept what the artist has put forth repeatedly: that the world is not made up of clean, linear and easily-reduced phenomena. However, as a scientific proposition, chaos theory's greatest achievement is that it began a process of facilitating communication between the various rock pools of knowledge that have shown their own peculiar form of self-similarity as a result of the Newtonian 'king tide' that receded during the nineteenth century. Because of chaos theory, non-linear approaches gained wider acceptance within the scientific community and helped reshape the manner in which the world and social systems are analogised. It is now the new 'interdisciplines' that are occupying its position as a point of 'social convergence', the most notable of which is complexity theory.[227]

[227] Aubin and Dalmedico, 'History of Dynamical Systems', p. 55.

3

Complexity and the Promise of Unpredictability

The endless cycle of idea and action,
Endless invention, endless experiment,
Brings knowledge of motion, but not of stillness;
Knowledge of speech, but not of silence;
Knowledge of words, and ignorance of the Word.
All our knowledge brings us nearer to our ignorance,
All our knowledge brings us nearer to death,
But nearer to death no nearer to God.
Where is the Life we have lost in living?
Where is the wisdom we have lost in knowledge?
Where is the knowledge we have lost in information?[1]

This chapter argues that the 'paradigmatic presupposition[s] of science'[2] have been challenged by the rise of the non-linear sciences and, consequently, the opportunity exists to re-cast the meta-theoretical foundations of social science. The Newtonian paradigm, which has framed what is knowable, what is known and how it should be known, is on the retreat and, as a result, social science has been freed from the polarising debates of positivists versus relativists. Further, the

[1] 'The Rock' in T. S. Eliot, *The Complete Poems and Plays, 1909-1950*, Harcourt Brace Jovanovich, New York, 1971, p. 96.

[2] Apel, 'The Hermeneutic Dimension of Social Science and its Normative Foundation', p. 250. Take, as a starting point, that 'It was a consequence of this paradigmatic presupposition of science, in general, that the novel problems of the "Geisteswissenschaften" and later of the *social sciences,* which emerged in the 19th century, were raised and treated as problems of a novel area of objectifying knowledge. This holds not only for the *naturalist and reductionist* epistemology and logic of "unified science"; it even holds for those who, like Dilthey, defended an epistemological and methodological difference, in principle, between "(hermeneutic) understanding" and "(nomomological) explanation" and hence between "Geisteswissenschaften" and "Naturwissenschaften."' ibid.

chapter argues that non-linear science can significantly contribute to the development of presuppositions that adequately capture the contextualisation and historicism that should be inherent in any social science. In pursuing this argument, the noteworthy developments that have contributed to the gradual acceptance of complexity theory as a theoretical approach are elucidated. In establishing paradigmatic boundaries that are of greater relevance for the study of social systems the argument upholds the necessity that an alternative theoretical starting point *must* have an explanatory component from which to build. This pursuit of explanation, however, continues to be shaped by the need for concrete answers and underlying absolutes. However, the aim of this chapter is also to establish new foundations so that the interactions of large numbers of agents that are considered to constitute a system can be imagined via the distinctive complexity worldview without resorting to the linear determinism and mono-causality of the Newtonian paradigm. To assist this approach, six presuppositions of complex systems are laid out. These are:

1. To remain viable, order in a complex system will *always* arise. A complex system cannot exist in a chaotic or anarchic state. Conversely, it cannot exist in a system that is too ordered or too stagnant.
2. Long-term prediction *is* impossible while short-term prediction is characterised by risk and uncertainty. However, pattern recognition via points of attraction is possible. These points are not permanently fixed and can shift.
3. Although bounded, the possible eventuality for any complex system is infinite. Precisely the same point is never subsequently achieved, due to the historical and endogenous nature of interactions.
4. Complex systems are open and do not possess a natural point of equilibrium to which all change is directed. There is no final end- point. Multiple systems can coexist, overlapping and existing in a nested environment. Boundaries, particularly in social systems, are not easily defined.

5. Emergence is the definitive value that captures complex systems. The system is more than its constituent parts in a relationship where both the whole and the parts influence and are influenced by each other. Being a non-additive process, the whole, quite simply, is not reducible.
6. Intuition *re-emerges* as a legitimate means of analysis for those seeking a scientific foundation, invited as opposed to dismissed by science. Interpretation and the qualitative appreciation of dynamic interactions offer a substantive position to analyse emergent phenomena. Intuition is released from its positivist prison, or, from the countervailing position, it can avoid the perceived slipperiness of unbounded reflectivism. This release is most pronounced in the *social sciences* that have been trapped by their own disciplinary foundations of pursuing scientific certainty.

A degree of overlap between each of the foundational statements is unavoidable, and is indicative of the interrelationships that underscore a complexity-based approach. It is equally important to appreciate that the six statements, delineated in this fashion, do not equate to axiomatic principles that are reminiscent of Newtonian-inspired approaches. What they represent, supported by developments in the non-linear sciences, is the establishment of a new paradigm that embraces an alternative belief system that allows us a significantly different worldview.[3]

In this chapter, complexity theory is presented as a gathering of interconnected ideas that form the basis of an understanding of how non-linear dynamical systems function and remain viable. It is the 'world' between order and chaos, how systems reside at a supposed, and imagined, 'edge of chaos', that this theory reveals. The result is to 'unconceal' an alternative worldview. The prevailing theme that continues to resurface is the need to be critical of reductionist methods and to accept that the whole is often more than the sum of the parts. Or put

[3] Remembering that any decision to pursue or adhere to a particular paradigm can only be faith based. See Kuhn, *Structure of Scientific Revolutions*, pp. 151, 158. Further, transferring an 'allegiance from paradigm to paradigm is a conversion experience that cannot be forced', ibid., p. 6.

differently, emergence needs to be central to attempts to theorise about systems that are complex, non-linear and adaptive.[4] To support this argument, the basic building blocks, the concepts that have supported the creation of complexity theory, are examined. Although seemingly quite abstract, these basic components inform how a non-linear world is imagined at the meta-theoretical level.

The process begins by looking at phase or state space; the place where complex systems are held in the mind's eye. Attractors and strange attractors within those spaces is where patterned behaviour is traced, and phase transitions inform the parameters held by systems within that space. What occurs in that space, where the convergence of complex systems to points conducive to their survival and maintenance occurs, is defined by the concepts of positive feedback, sensitivity to initial conditions,[5] self-organisation (including self-organised critically which looks at the emergence of tipping points), and the second law of thermodynamics (entropy). These are the substantive ideas that inform the non-linearity and openness identified with this approach, and that have allowed the development of complex theory. The need to examine these concepts lies in expanding how they influence the trajectory (or trajectories) of a system, how they challenge additive-derived inferences, the manner in which they acknowledge the endogenous nature of change, and the realisation that they all play an important role in producing a theory of emergence.[6] It is these fundamental notions that have direct bearing upon how social systems can, and should, be imagined. Moreover, the cumulative idea that emerges from these building blocks is the now popularised (and methodologically abused) complex adaptive system.[7] As an idea the complex adaptive system is appealing, as it gathers these various concepts together and reformulates them in a neat systems-based approach that acknowledges the constitutive nature of interactions. It is an approach that has immediate resonance and applicability to the study of social systems. It is important, however, to

[4] This will be shown in chapters four and five to include the international system.
[5] Also known as the butterfly effect where small changes in the starting conditions can result in wildly divergent outcomes.
[6] On emergence see Goldstein, 'Emergence as a Construct', pp. 49-72.
[7] How the complex adaptive system is related to international relations is pursued in Chapter Five.

recognise that this 'new science', to borrow a term from Vico, does not rest on a final cause or a teleological end-point. Similarly, it has not, and may well not, reach a definitive conclusion as to its exact form as a separate theory. It certainly will not provide axioms from which additive conjecture can be formulated. What it does do, however, is to offer a non-prescriptive, non-linear and non-additive[8] scientific paradigm for understanding how *things* or agents interact, how boundaries are created and how human imagination orders the world around.

One of the most significant legacies of chaos theory was the bringing to prominence, and the connecting together, of an array of thinkers from different disciplines who were, in their own way, attempting to work out how to best approach non-linear dynamical systems. From this, complexity theorists in their infancy started to surface and, through their work, communication and with the gradual establishment of institutions,[9] a classification process began. In essence, a grouping of common attributes that could be incorporated into a general theory was underway. Of course, any complexity theorist is quick to point out that any such groupings are fluid, and that there is still much to learn. Indeed, in laying down the perceived principles of complexity theory, it is important to avoid slipping into unhelpful relativism or absolute universalism.[10] However, despite this fluidity, some general concepts have become accepted parlance within the field. With this in mind, the argument strengthens claims that bounded rationality is of major importance in any effort to understand the significance of intersubjective cultural or norm-based constructions of agents within systems.[11]

---

[8] Non-additive means that a system 'cannot be understood by adding together the units or their relations'. Jervis, *System Effects*, p. 6.

[9] Most notably the Santa Fe Institute, go to: http://www.santafe.edu. See also the New England Complex System Institute, go to: http://necsi.org/ and The Center for Complex Systems Research, (University of Illinois), go to: http://www.ccsr.uiuc.edu/. There was also the now defunct European Consortium (funded by the European Union) EXYSTENCE – Complex Systems Network of Excellence, see: http://ecss.csregistry.org/tiki-index.php?page=Exystence+focus+documents.

[10] In part because of the inherent uncertainty and the narrow gauntlet that complex systems reside upon.

[11] Many examples support this view. For example see W. Brian Arthur, 'Complexity in Economic Theory: Inductive Reasoning and Bounded Rationality', *American Economic Review*, vol. 84, no. 2, 1994, pp. 406-11 and Geoffrey M. Hodgson, 'Evolutionary and Institutional Economics as the New Mainstream?', Evolutionary and Institutional Economics Review, vol. 4, no. 1, 2007, pp.7-25.. As points of interests see also Ted Hopf, *Social Construction of International Politics: Identities & Foreign Policies, Moscow, 1955 and 1999*, Cornell University Press, Ithaca, 2002, esp. pp. 1-33; Harald Müller, 'Arguing, Bargaining and all

Similarly constrained by paradigmatic parameters, the importance of the scientific imagination has been elevated as a primary sub-theme, not least how it reflects upon notions of order and certainty, so as to reinforce that certainty has not always been certain. Certainty, enshrined by notions of universalism, linearity and a perception that order had banished chaos, was born from the acceptance of a distinct paradigm. The biological sciences are an excellent example of an area that has not only driven much of the research agenda within the realm of complexity science, but has had difficulty 'fitting in' with the Newtonian paradigm. Biology is not a 'neat' science. Axiomatic laws of motion (or at least the fixation on the reductionist propositions that emerge from them) do not necessarily pertain easily in it. Consequently, during the Newtonian and positivists' 'revolutions', biology, or at least elements of evolutionary science, confounded the Newtonian imagination.[12] In short:

> While Newton and the physicists had staggered the imagination of the Enlightenment with simple Formulae that were universally applicable to matter in motion, the biologists who followed them struggled with a complexity that resisted rational analysis.[13]

However, the paradigm, as these so often do, prevailed with the rationalist morphologists pushing their taxonomies and classifications upon an accepting scientific community.[14] Biology was made to fit this. Add to this the Spencerian ideal of survival of the fittest,[15] and the notion of linear progression in the

---

that: Communicative Action, Rationalist Theory and the Logic of Appropriateness in International Relations', *European Journal of International Relations*, vol. 10, no. 3, 2004, pp. 395-435; George Lawson, 'The Promise of Historical Sociology in International Relations', *International Studies Review*, vol. 8, no. 3, 2006, pp. 397–423.

[12] Kauffman, *At Home in the Universe*, p. 7. And with this should come the observation that the Newtonian worldview can only ever provide 'a partial view of "reality"', Mathews, et al., 'Why Study the Complexity Sciences', p. 453.

[13] Stempel, 'Angels of Reason', p. 70.

[14] Kauffman, *At Home in the Universe*, p. 7.

[15] Herbert Spencer selectively interpreted Darwin. It was Spencer, in the positivist tradition, not Darwin who gave the world the popular, loaded and often vexed term 'survival of the fittest' (as earlier as 1850 or 1852). See Jonathan H. Turner, 'Durkheim's And Spencer's Principles of Social Organization: A Theoretical Note' in John Offer, ed., *Herbert Spencer: Critical Assessments of Leading Sociologists*, vol. 2, Routledge, London, 1999, p. 322. In the same volume see also Robert C. Bannister, "The Survival of the Fittest is Our

biological sciences had achieved law-like status. In this respect, Darwinian perspectives can be seen as a catalyst for re-enforcing notions of the linearity of scientific understanding. More worryingly, the leap from studying the biological sciences to studying social systems, impressionistically, appears less challenging.[16] This scientific drive towards linearity can be clearly witnessed by the similarity found in biology with the ideas of geological gradualism, whereby, like Descartes' tree of knowledge, evolution was seen to occur via a slow accumulation of favourable variations.[17]

Cartesian thought, which had been absorbed into the dominant paradigm, still formed a major part of the worldview. Of Descartes's four rules of logic, consider his second, in which he committed to the necessity of dividing 'each of the problems that [he] was about to examine into as many parts as possible and as necessary to resolve them better'.[18] This rule only served to constrain ideas to a linear understanding of the world. This was re-enforced by his third rule that revealed the inherent reductionism from which the world was and, in varying degrees, continues to be analogised. Indeed, it is from this vein of Enlightenment thought that genetic reductionism, as an absolute and axiomatic staring point, can

---

Doctrine": History or Histrionics?', in ibid., pp. 165-85. Closest to this sentiment in Darwin's *Origin of Species*, and important in the context of this chapter, is found in his preamble to the introduction of his newly coined term 'natural selection' where 'Owing to this struggle for life, any variation, however slight and from whatever cause proceeding, if it be in any degree profitable to an individual of any species, in its infinitely complex relationship to other organic beings and to external nature, will tend to the preservation of that individual, and will generally be inherited by its offspring', Charles Darwin, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*, 1st ed. (reprinted), Watts & Co., London, 1950 [1859], p. 10. Yet many years later Darwin slips into the social realm, attaching to the notion of civilisation, stating that 'With highly civilised nations continued progress depends in a subordinate degree on natural selection; for such nations do not supplant and exterminate one another as do savage tribes. Nevertheless the more intelligent members within the same community will succeed better in the long run than the inferior, and leave a more numerous progeny, and this is a form of natural selection. The more efficient causes of progress seem to consist of a good education during youth whilst the brain is impressible, and of a high standard of excellence, inculcated by the ablest and best men, embodied in the laws, customs and traditions of the nation, and enforced by public opinion,' Charles Darwin, *Descent of Man*, [1871], p. 220. In the *Descent of Man*, Darwin does make mention of 'survival of the fittest'. ibid., pp. 81, 101.

[16] See Duncan Bell, 'Beware of False Prophets: Biology, Human Nature and the Future of International Relations Theory', *International Affairs*, vol. 82, no. 3, 2006, pp. 493-510.

[17] Kauffman, *At Home in the Universe*, p. 13.

[18] Descartes, *Discourse on Method*, Part II, p. 16.

be understood to have surfaced.[19] Accepting Descartes's third rule only reaffirms how the historical development of ideas has occurred as it means, in his words, to always begin:

> with the objects that are the simplest and easiest to know and to rise gradually, as if by steps, to knowledge of the most complex, and even by assuming the same order among objects in cases where there is no natural order among them.[20]

The argument set out here is that of constructing a different paradigm, one that accepts the non-linearity of dynamical systems (including human systems). What is to emerge through this chapter is the proposition that human societies, and in particular politics in general, cannot, or should not, 'be understood from a traditional linear perspective where the magnitude of a cause is directly proportional to the magnitude of its effect'.[21] So begins the process of accepting that the proliferation and the increased complexity of relationships between agents results in a situation where it is increasingly difficult to maintain strict observance of any theoretical framework that is a derivative of the positivist tradition.[22] Indeed, the very rationality of agents is delimited by a system where rationality is subject to time and context, [23] complicating positivist research agendas. Add to this that human rationality in itself is bounded, as 'beyond a certain level of complexity human logic ceases to cope'.[24] It then becomes evident

[19] For an interesting overview see D. L. Hull and M. van Regenmortel, eds, *Promises and Limits of Reductionism in the Biomedical Sciences*, John Wiley and Sons, New York, 2002, esp. Kenneth F. Schaffner, 'Reductionism, Complexity and Molecular Medicine: Genetic Chips and the 'Globalization' of the Genome', pp 323-51. For a critique see Kathleen McAfee, 'Neoliberalism on the Molecular Scale: Economic and Genetic Reductionism in Biotechnology Battles' *Geoforum*, vol. 34, 2003, pp. 203–19. On the impact of an evolutionary reductionist framework upon international relations see Thayer, *Darwin and International Relations*. On the dangers of this approach see Bell, 'Beware of False Prophets', passim.
[20] Descartes, *Discourse on Method*, Part II, p. 16. Descartes three remaining rules are: 'The first… never to accept anything as true that I did not plainly know to be such; that is to say, carefully to avoid hasty judgment and prejudice… And his fourth: 'everywhere to make enumerations so complete and reviews so general that I have assured of having omitted nothing.' ibid.
[21] Gregory G. Brunk, 'Self-Organized Criticality: A New Theory of Political Behaviour and Some of Its Implications', *British Journal of Political Science*, vol. 31, no. 2, 2001, p. 427. A point pursued more forcefully in the following two chapters.
[22] Geyer, 'Globalization, Europeanization, Complexity' , p. 561.
[23] ibid.
[24] Arthur, 'Complexity in Economic Theory', p. 406. It is also important to note that reductionism at some level cannot be escaped as 'Human sensory observation is reductionist by definition, as it basically consists of a serial registration of elementary sensations. The observer necessarily focuses on one or more aspects or

that the dominant outlook seeks only to simplify to allow a level of comprehension, not necessarily to advance an understanding of the richness of the environment under scrutiny. To press it further, quantitative methods that focus on measuring complex systems, which cannot help but to compose the elements to be measured, run the risk of excluding what is essential for understanding.[25] Drawing elements of reflexive thought into this scenario further complicates matters. Effectively, quantitative methods that draw from a methodological reductionist base have difficulty accommodating feedback, which supports the notion that subject and object are constituted by each other 'through recurrent practices'.[26] In this situation, the concept of perfectly rational agents operating in a linear world is seriously weakened. This will be extended to show the limited nature of those theories that suggest an optimal fitness of agents within a given system is discernable.[27] Such a limitation is shown to occur because the vast number of possibilities within a dynamical system means agents 'have no practical way of finding the optimum'.[28] The introduction of complexity theory is not about reaching a middle way, a compromise or a point of utility, but offering a different meta-theoretical foundation that accepts that 'living' systems emerge and exist in a space that is neither ordered nor chaotic.

However, before proceeding any further, it is necessary to reflect on the underlying assumptions that underpin complexity theory as a legitimate means of analysis in the social science stable. As a *means* of understanding, it allows for the imagining of a new landscape that is continually in the process of being mapped and that it is not a map that can ever reach a final point. This is not to diminish its

particles of an object at a time. So in a sense almost every observation more or less is reductionist in nature.' Piet J. M. Verschuren, 'Holism versus Reductionism in Modern Social Science Research', *Quality and Quantity*, vol. 35, no. 4, 2001, p. 393.

[25] Margaret Somerville, 'Reductionism v Complexity: A Canary in the Bioethics Crossfire', *Quadrant*, vol. 45, no. 7-8, 2001, p. 31. This is not suggest that measurement should not take place, just that when it does there *must* be an acknowledgment that part of the picture is lost and measured results in complex systems can never be definitive.

[26] Knutsen, A *History of International Relations Theory*, p. 280. This, of course lends itself to constructivist thought. See Chapter Four and especially Chapter Five.

[27] In relation to economics see following chapter.

[28] John Holland quoted in Richard Bronk, *Progress and the Invisible Hand: The Philosophy and Economics of Human Advance*, Little, Brown and Company, London, 1998, p. 199.

usefulness, as developing an understanding of the terrain that accepts the inherent amorphousness of social systems and structures will allow for richer interpretative analysis. Moreover, and as the next section details, as a new approach it is the conceptual and paradigmatic schism that it reveals and exploits that allows it, as an idea, to gain traction.

New Theoretical Terrain

Complexity theorist and molecular biologist John Holland notes that 'with theory, we can separate fundamental characteristics from fascinating idiosyncrasies and incidental features'.[29] In social systems, this constitutes the examination of relationship patterns amongst groups and individuals.[30] The theoretical approach ascribes significance to particular relationships, and the role and roots of knowledge, and hence power,[31] dictates the understanding of these 'fundamental characteristics'. The introduction of new theories such as complexity challenges epistemological and ontological foundations by diving into the vast 'sea of ignorance' that separates the various 'islands of truth'.[32] As has been argued, the dominant 'islands' within this metaphor emerged from the Scientific Revolution and the Enlightenment, and continue to accord centrality to human rationality, coupled with the ability to understand and control the natural environment. In essence, science and human reason surfaced from this new period of intellectual exploration with claims of universal laws, predictability, and order.[33] Yet, despite the successes of science to simplify and explain certain phenomena, the issue of complexity (as opposed to simplicity) has defied explanation by reductionist methods.[34] Complexity, in this sense, refers to the emergent phenomena that arise through the interaction of parts. It is here that traditional models and thinking have had difficulty accommodating events and circumstances that have not

[29] Holland, *Hidden Order,* p. 5.
[30] Anthony Giddens, *Sociology: A Brief but Critical Introduction*, MacMillan Press, London 1982, p. 14.
[31] This is discussed at length in Chapter Four.
[32] Cohen and Stewart *The Collapse of Chaos,* p. 2. Remembering, of course, that not all new theories learn to swim with many quickly sinking to the bottom or floundering in the shallows.
[33] Geyer, 'Globalization, Europeanization Complexity', p. 564.
[34] Wolfram, *A New Kind of Science*, p. 2.

followed a linear progression. Irregularities were either ignored or made to fit.[35] The inability to come to terms with the holistic nature of a complex system stems from traditional methods whereby if something has been too complex to understand as a whole, it has been divided into manageable units, analysed, and then put back together again, potentially destroying whatever it was that was trying to be understood.[36] The very essence of complexity theory suggests that function and structure should not be viewed 'as "independently observable" phenomena' that are reducible components of a system.[37] Physicist and Nobel laureate Murray Gell-Mann supports this view, stating that:

> The process has gone so far that we human beings are now confronted with immensely complex ecological, political, economic and social problems. When we attempt to tackle such difficult problems, we naturally tend to break them up into more manageable pieces. That is a useful practice, but it has severe limitations. When dealing with any non-linear system, especially a complex one, you can't just think in terms of parts or aspects and just add things up and say that the behaviour of this and the behaviour of that, added together, makes the whole thing. With the study of a complex non-linear system you have to break it up into pieces and then study each aspect, and then study the very strong interaction between them all. Only this way can you describe the whole system. In this sense there is truth in the old adage that the whole is more than the sum of its parts.[38]

Complexity theory's prominence has been increasing in recent years, yet has not entirely stepped from the shadow of chaos theory. Gell-Mann amusingly recounts his frustration with repeatedly being congratulated at the end of a public lecture for his interesting talk on 'chaos', when he was in fact giving a lecture on complex phenomena.[39] The perceived similarity understandably creates an element of

[35] Again, see Kuhn, *Structure of Scientific Revolutions*, passim
[36] Cilliers, *Complexity and Postmodernism*, pp. 1-2.
[37] Yong Pil Rhee, 'Complex Systems Approach to the Study of Politics', *Systems Research and Behavioural Science*, vol. 17, no. 6, 2000, p. 487. With this in mind the agent-structure debate is unpacked in the final chapter.
[38] Murray Gell-Mann , 'The Simple and the Complex', in Alberts, David S., and Czerwinski, Thomas J., (eds.), *Complexity, Global Politics, and National Security*, National Defence University, Washington D.C., 1997, p. 19.
[39] Gell-Mann, *Quark and the Jaguar*, p. 27.

confusion, chaos theory being easily described as having a paternal link with the evolution of complexity theory. Part of the issue rests with the difficulty in defining complexity theory in a reasonably succinct manner. Michael Simmons, former director of the Santa Fe Institute, was quick to point out in the mid-1990s that there was no consensus as to what actually constituted complexity theory, with there being a diversity of definitions that had been spawned from many different fields.[40] This appeal across a broad base, assisting the communication between the various intellectual 'rock pools', is, to rely on an overused turn of phrase, both its strength and weakness. The strength lies in the pressure it places upon reductionist understandings across a broad spectrum, denoting its significant presence as an encompassing paradigm. Its weakness is in its broad appeal as pseudo- or pop science, providing legitimacy to any position that stands in opposition to positivist accounts, and doing so with little explanation as to what *it* is and how a *science* of complexity informs debates within the philosophy of science and the social sciences. Complexity theory is not a panacea; however, it does offer new conceptual tools for thinking about social phenomena that have stubbornly refused to be boxed by current approaches and those which have snubbed attempts at prediction.

This is not to suggest that many of the ideas emerging from complexity theory are necessarily new or original, although some are. But what it represents is an explicit gathering of ideas under the one theoretical umbrella of non-linear science. The versatility of complexity theory can also be attributed to this usage across an impressively diverse range of academic fields, by those attempting to move away from mechanistic and reductionist understandings.[41] IR theorist James Rosenau has noted, echoing the above point, that:

---

[40] William Tucker, 'Complex Questions: the New Science of Spontaneous Order', *Reason*, vol. 27, no. 8, 1996, p. 35. The Santa Fe institute is often held to be the premier establishment for the study of complex systems.

[41] Soren Holm, 'Does Chaos Theory have major implications for Philosophy of Medicine', *Journal of Medical Ethics: Medical Humanities*, vol. 28, 2002, p. 78. Soren, who predominantly misrepresents complexity theory, also correctly notes the importance of distinguishing 'between practical unpredictability and true randomness or non-determination'. His focus on causality idealises complexity theory as merely complicating causal relationships resulting in an ultimately and inescapable reductionist outlook. ibid., pp. 80-1.

> Although complexity theory is still very much a newcomer in the storehouse of social science tools, many analysts have shared its underlying propositions [and its newness is in] … the explicitness and integration of these premises into a coherent whole that facilitates inquiry.[42]

With this, and after a long gestation, those defending the paradigm (and the same can be said of those whose opposition to a 'homogenising' or 'imperial' worldview are built upon the same foundations) need to accommodate the pressure of this alternative paradigm. Gell-Mann stressed the difficulty in attempting such a lateral movement of the scientific imagination, when he noted how unfortunate it is that 'in a great many places in our society, including academia and most bureaucracies, prestige accrues principally to those who study carefully some aspect of a problem, while discussion of the big picture is relegated to cocktail parties'.[43] Yet words of warning should follow, as those seeking a new methodological approach should not be immediately overcome with enthusiasm. Many examples of the direct application of complexity theory are overly earnest and elicit a fallacy. This occurs because some researchers have used complexity theory as a description of reality, when in fact they have merely offered a metaphor that suits their purposes. Metaphorically, complexity theory is attractive and it has grounding in science, but its 'ontological adequacy' as a direct methodological application should not be overstated. The single most important contribution that complexity theory offers is in the development of abstractions,[44] and the central argument is that it offers *most* at the meta-theoretical and foundational level. As a simple methodological application it is easily portrayed as just another theory competing in the storehouse of theoretical approaches.

Finally, it must be added that bridge-building within a single discipline is a difficult task in itself, but doing so between the physical and social sciences often

---

42 James Rosenau, *Distant Proximities: Dynamics Beyond Globalization*, Princeton University Press, Princeton, 2003, p. 207.
43 Gell-Mann 'The Simple and the Complex', p. 15. See also: Gell-Mann, *Quark and the Jaguar.*
44 Ted Fuller and Paul Moran, 'Moving Beyond Metaphor', *Emergence*, vol. 2, no. 1, 2000, p. 52.

invites the further criticism of 'physics envy'. Anthony Giddens stressed that 'we cannot approach society, or "social facts", as we do objects in the natural world', as it is misleading to suggest that patterns are 'like the walls of a building, or the skeleton of a body' due to the static nature of such objects. He suggests that if such imagery is to be used, then 'social systems are like buildings that are at every moment constantly being reconstructed by the very bricks that compose them'.[45] Giddens's argument is persuasive, and to underscore the inapplicability of the 'hard' sciences he refers to the constant dynamism within social systems. However, many of the concepts he refers to, including reproduction and repetition, double involvement[46] and subject-matter relationships, bear a remarkable resemblance to many of the characteristics found within complex systems.[47] It quickly becomes apparent that his criticism is predominately directed towards the Newtonian and reductionist methods of traditional science. Rosenau may well suggest that Giddens is one of those who has 'always been a rudimentary complexity theorist' before its recognition as a stand-alone field of inquiry.[48] With a degree of irony, James Gleick, who launched chaos theory into the popular imagination, supports Giddens' position. For Gleick, understanding a non-linear system is analogous to 'walking through a maze whose walls rearrange themselves with each step you take',[49] basically because such systems are rarely comprised of simple properties and laws found in linear systems that allow predictable and ordered pattern recognition.[50]

Adding weight to this perspective, and very much capturing the ethos of complexity, physicist Paul Davies reinforces the importance 'that there are systems the behavior of which can be understood only by looking at the collective

[45] Giddens, *Sociology: A Brief but Critical Introduction*, pp. 13-14. Giddens is critical of both Comte and Durkheim when suggesting this. ibid pp. 12-15.
[46] Giddens refers to 'double involvement' as the process in which 'we create society at the same time as we are created by it'. ibid. p. 14.
[47] ibid., pp. 14-15.
[48] Rosenau, *Distant Proximities*, p. 207.
[49] Gleick, *Chaos,* p. 24. See also Geyer, 'Future of Scandinavian Exceptionalism', p. 566. This is also reminiscent of what Kauffman (see below) refers to as taking 'a walk in parameter space'. Kauffman, *Origins of Order*, p. 210.
[50] Gleick, *Chaos*, p. 80.

and organizational aspects, instead of the individual constituents'.[51] What follows is more than a description of what complexity theory *is*. The argument is that it is important to understand and incorporate non-linear perspectives into the foundation of theories. Doing so will allow theories that draw from a social scientific base to 'unconceal' more *realistic* explanations of emergent, unpredictable and non-reductionist patterns of behaviour. It is these ideas that, in chapters four and five, inform the critique of mainstream IR theory and how it might be conceptualised differently. The building blocks of complexity theory are each, in turn, introduced, analysed and ultimately incorporated into a general theory of a complex adaptive system. The process first begins at the most abstract level, that is, the imagined space, the state or, more commonly expressed, phase space that a system may be visualised, plotted and convergences established. This represents an essential starting point, as a great deal of the development of complexity theory has occurred in this conceptual space.

Phase Space

The argument to re-establish presuppositions that support a non-linear, complexity-inspired paradigm must clarify how the conceptual space from where they are derived is formulated. Consequently, the importance of this section lies in tracing how, first, the sciences in general track the temporal dimensions of a system and, secondly, the differentiation that occurs when undertaken by complexity-based sciences.[52] In both cases, this is undertaken by monitoring the interaction between the temporal and spatial variables that is significant in respect to 'observing' the trajectory of a system.[53] The primary way this is visualised is via the concept of 'phase space'.[54] The ability to 'track' these movements allows for a

[51] Paul Davies, 'The Synthetic Path' in John Brockman, ed., *The Third Culture: Beyond the Scientific Revolution*, Simon & Schuster, 1995, http://www.edge.org/documents/ThirdCulture/za-Ch.18.html, accessed 17/02/2006.
[52] See David Byrne, *Complexity Theory and the Social Sciences: An Introduction*, Routledge, London, 1998, pp. 24-6
[53] Mathews, et al., 'Why Study the Complexity Sciences', p. 443. It is worth acknowledging that complex systems can have 'multiple trajectories'. Byrne, 'Complexity, Configuration and Cases', p. 97.
[54] The use of the word 'phase' is in actuality an historical anomaly that bears no relevance today and the phrase 'state space is sometimes used in its place. Gribbin, *Deep Simplicity*, p. 42. For example Kauffman refers to 'state space', see *At Home in the Universe*, passim and *Origins of Order*, passim.

'landscape' to emerge that highlights patterned behaviour. Indeed, topologically 'phase space can be thought of as like a landscape, with rolling valleys, deep potholes, hills and mountains',[55] which, at the very least, accommodates new methods of analogising the movement of systems. At its most basic level of explanation, phase space can be described as a method to map:

> all the possible states of a system into a space defined by a set of dimensions, each of them corresponding to a parameter of the system. Through a continuous change in these parameters, any change in the system will be modelled by a trajectory in the phase space. Classical conservative mechanical systems will result in one distinct trajectory through the phase space, but various dampened, thermodynamic systems lose energy all along and may approach the same behaviour as systems with other initial conditions. [56]

It is important to recognise when tracking any system through phase space that evolves through time that it will always be multidimensional.[57] This, of course, makes the concept quite difficult to imagine. However, it provides the infinite, yet bounded, possibilities within the theoretically-drawn phase space. At the practical level, and there is often some confusion here, a 'phase portrait' or a 'phase diagram' may also be generated by compiling repeated snapshots that track the so-called movements within phase space.[58] The difference between the non-linear and the linear is particularly pronounced when tracking a 'simple' and deterministic Newtonian system through phase space:

> The general law deduces from the 'initial state' the series of states the system passes through as time progress, just as logic deduces a conclusion from basic premises. The remarkable feature is that

[55] Gribbin, *Deep Simplicity*, p. 44. 'In the study of physical systems, it has become customary to undertake this pursuit in terms of phase space of a system, such that the points in this space represent instantaneous descriptions of system status at different points in time.' in Chatterjee and Yilmaz, 'Chaos, Fractals and Statistics', p. 53-4.

[56] Claus Emmeche, Simo Køppe and Frederik Stjernfelt, Levels, Emergence, and Three Versions of Downward Causation', in: Peter Bøgh Andersen, Claus Emmeche, Niels Ole Finnemann and Peder Voetmann Christiansen, eds, Downward Causation: Minds, Bodies and Matter, Århus, Aarhus University Press. 2000, pp. 26-7

[57] Stewart, 'Portraits of Chaos', pp. 46-7.

[58] Bob Johnson, 'An Example of Chaotic Dynamics', *Mathematical Gazette*, vol. 74, no. 469, 1990, pp. 258-9.

> once the forces are known, any single state is sufficient to define the system completely, not only its future but also its past. At each instant, therefore, everything is given.[59]

The linearity is most evident when characterised by movement through time, as it is theoretically reversible, and it is reducible to its underlying premise, meaning that its movement through the space becomes entirely predictable. Regions that become 'occupied', that is the space in which systems are 'attracted' to, within phase space are known as attractors. To explain:

> An *attractor* is the name of a set of points in the phase space in which trajectories with many different initial conditions end. Attractors may vary in kind from points (corresponding to no change in the system), to orbits (corresponding to cyclically recurrent states), to pseudo-cycles (corresponding to overall but not precisely recurrent behaviour), and the strange attractors of chaos theory (with unpredictable behaviour due to exponentially divergent trajectories from nearby points -- but still with pattern properties).[60]

Attractors occupy a very small region when compared to the overall volumes of states within any given basin. Effectively, a boxing of the system occurs with the attractor holding the system unless it is disturbed by an external factor or force.[61] Indeed, these basins of attraction occur in self-organising systems, as Stuart Kauffman explains:[62]

> since the system follows trajectories that inevitably flow into attractors, tiny attractors will 'trap' the system into tiny

---

[59] Prigogine and Stengers, *Order Out of Chaos*, p. 60.

[60] Emmeche, et al., 'Levels, Emergence, and Three Versions of Downward Causation', p 27. They continue: 'Attractors are of course not unique to emergent behaviour (unless all thermodynamic micro-macro distinctions involve emergent behaviour), but it seems to be the case that emergent higher levels are regulated by stable and complicated attractors for the dynamics of the lower level, often characterized by cyclical mechanisms of regulation.' ibid.

[61] Kauffman, *Origins of Order*, p. 177. Moreover, 'In the absence of significant perturbations, a dissipative system will usually follow a "normal" linear trajectory', Harvey and Reed, 'The Evolution of Dissipative Social Systems', p. 385.

[62] Kauffman, *At Home in the Universe*, p. 78. In the language of dynamical systems the state cycle is an attractor and the collection of trajectories that flow into it is called the basin of attraction. We can roughly think of an attractor as a lake, and the basin of attraction as the water drainage flowing into that lake. ibid., p. 78. Basically, 'lakes correspond to a point; drainage basins, to the basins of attraction', Kauffman, *Origins of Order*, p. 176.

subregions of its state space. Among the vast range of possible behaviours, the system settles into an orderly few. The attractors if small create order. Indeed tiny attractors are a prerequisite for the order for free…[63]

Moreover, for complexity theorists, it is the 'strange' attractor that is of most interest; that is, those 'attractions' of trajectories that could not occur within a conservative system, a point Kauffman would most certainly agree with.[64] The discovery of strange attractors led to a fundamental shift by researchers during the 1970s. Very rapidly, a greater concentration and effort was focussed on examining those irregular patterns that arose via an array of processes that in the past had been merely dismissed as 'misfits':[65]

> Strange attractors are those patterns which characterize the final state if dissipative systems that are highly complex and show all the signs of chaos. They very strongly defy the power of an intuitive understanding, and yet they are now proven to be all around us. Moreover, strange attractors are the point where chaos and fractals meet in an unavoidable and most natural fashion: as geometrical patterns, strange attractors are fractals; as dynamical objects, strange attractors are chaotic.[66]

For those studying complex systems, the Lorenz attractor is the most recognised.[67] Lorenz's achievements are detailed below; however, it is the notion of bifurcation that resurfaces at this point. As was depicted in the last chapter, utilising Hokusai's painting *The Great Wave*, bifurcation involves the splitting and divergence from a similar starting position, and within the study of dynamical

---

[63] Kauffman, *At Home in the Universe*, p. 79. It should be remembered that 'attractors literally are most of what a system does', Kauffman, *Origins of Order*, p. 174. See also David V. Newman, 'Emergence and Strange Attractors, *Philosophy of Science*, vol. 63, no. 2, 1996, pp. 245-61.

[64] Mirowski, 'From Mandelbrot to Chaos in Economic Theory', p. 302. A strange attractor can only occur in the phase space of dissipative systems whereby the 'dimension' within the 'geometric characterization' are lowered because of the dissipation (i.e. energy/entropy). ibid. Earlier, Mandelbrot took a dislike to the use of the word 'strange' in the strange attractor (as the Mandelbrot set is one of the most recognised chaotic attractors) as he felt that he had illustrated 'that fractals are not stranger than coastlines or mountains' in the world around us. Mandelbrot, *Fractal Geometry*, p. 198. Acknowledging Mandelbrot's work, Kauffman posits that a strange attractors dimensionality is defined by a 'fractal dimension', Kauffman, *Origins of Order*, p. 179.

[65] Peitgen, et al, *Chaos and Fractals*, p. 657. For Mandelbrot, although Poincaré did not foresee fractal geometry he was the first student of strange attractors. Mandelbrot, *Fractal Geometry*, p. 414.

[66] ibid., p. 656.

[67] Also known as the butterfly effect. See below.

systems it is one of the most acute processes, [68] underpinning an essential element of strange attractors:

> the interesting property of such attractors is that, if the system is released from two points on the attractor which are *arbitrarily close* to each other, the subsequent trajectories remain on the attractor surface but *diverge away* from each other. After a significant time flowing on the attractors the two trajectories can be arbitrarily far apart on it.[69]

From this point it can be asserted that slow changes to the parameters of a given system will not necessarily translate directly to similar and proportional changes to the trajectory of that system. Yet a change, however small, may induce a sudden divergence, bifurcations that will represent a change in behaviour. Here, the system is at its frontier.[70] Further, a system will 'jump' or bifurcate until a 'good attractor' emerges, essentially taking what Kauffman refers to as a 'walk in parameter space'.[71] However, as a final, and important, point on mapping systems within an imagined phase space, it must be realised that:

> Each region of phase space may contain an infinite number of representative points the density of which measures the probability of actually finding the system in this region. … Presented in such a way, the density function … may appear as an idealization, an artificial constraint, whereas the trajectory of a point in phase space would correspond 'directly' to the description of 'natural' behaviour. But in fact it is the point, not the density that corresponds to an idealization. Indeed, we never know an initial state with an infinite degree of precision that would reduce a region in phase space to a single point; we can only determine an ensemble of trajectories starting from the ensemble of representative points corresponding to what we know about the initial state of the system.[72]

---

[68] Kauffman, *Origins of Order*, p. 180. For example (and a popular one at that), 'the onset of turbulence in a fluid flow' occurs when 'some critical velocity is reached is reached [and] there either is or is not an eddy'. ibid.

[69] ibid., p. 178.

[70] Stäheli, 'The Outside of Global', p. 17.

[71] Kauffman, *Origins of Order*,, p. 210. These critical ideas for understanding complex systems are elaborated further below.

[72] Prigogine and Stengers, *Order Out of Chaos*, pp. 247-8.

Kauffman refers to an 'ensemble of dynamical systems', introducing the 'notion of a system and its neighbors within a small volume of parameter space',[73] portraying a strong connection to how the idealisation of points of density within a given system are understood. In reference to the international system, connections to multiple and overlapping systems as opposed to an idea of a singular and homogonous system can be properly appreciated. Commonalities exist within and between systems, and there are points of reference, but the systems cannot be fixed on a single point. This fits neatly with the idea of 'nesting' ideas and realities, and the infinite and unpredictable nature of each. Take from this that every social, cultural, linguistic or even artistic act can only represent a point in reality. Languages in all their diversity 'only express a part of reality'; similarly, music 'by any of its realizations, by any style of composition' cannot be exhausted.[74] Music, art, and attempts to understand the social, can *never* be exhausted. The next section continues this argument, introducing explicitly the concept of feedback.

Feedback

Feedback is the process that sustains the infinite possibilities mentioned above. The uniqueness of every interaction occurs as each is informed by a dynamic history of previous interactions. In every way this is a dialectic process that continues *ad infinitum.* Two points here need to be made. First, it is a concept that flows through the various subheadings and is not easily, in the spirit of complexity theory, contained exclusively within a single section. The effect of feedback is evident within all the subsections dealt with here. Second, it is far from a new concept within the social sciences, yet complexity theory offers new insights as to how these constant loops within systems can be appreciated. Fundamental to developing this appreciation is the idea that scaling occurs. This means that loops of differing magnitudes can feedback immediately or can occur further down the time scale, accentuating the continual shifting and readaptation of a system (which

[73] Kauffman, *Origins of Order*, p. 210.
[74] Prigogine and Stengers, *Order Out of Chaos*, p. 225.

will be shown to be a complex adaptive system) within its conceptual phase space. Moreover, it is important to generate an awareness that feedback is conceptualised as being both positive (enhancing, away from equilibrium) and negative (detracting, towards equilibrium).[75] The distinction between positive and negative feedback is a defining point of complexity theory, and one that gives significant weight to critiques of social scientific theories that seek or suggest a natural order based on a natural equilibrium.

At the most basic level, since the time of Newton and Leibniz, negative feedback processes have been fundamental to approaches in the exact sciences.[76] Yet, feedback within non-linear system refers to positive, or away-from-equilibrium variety 'in which changes are amplified, breaking up existing structures and behaviour', and in the process 'creating unexpected outcomes in the generation of new structure and behaviour'.[77] Randomness, irreversibility[78] and dissipative structures are tied into feedback,[79] with the effects being said to occur 'between macroscopic structures and microscopic events'.[80] Self-organisation is expanded upon below, but it is worth emphasising that '[s]elf regulating processes' are a form of negative feedback, and 'self-augmenting processes' are a form of positive feedback. These characterisations not only produce powerful generalisations for comprehending the dynamic interaction in complex systems, but they also offer a distinct method for analysis across disciplines.[81] At the level of analogy the most significant representation of positive feedback that has made the successful leap from the sciences into the social and popular imagination, even if abused, is the butterfly effect. Thus, in order to continue the argument that far-from-equilibrium

---

[75] Cilliers, *Complexity and Postmodernism*, p. 4.
[76] Peitgen, et al, *Chaos and Fractals*, p. 17.
[77] Euel Elliot and L. Douglas Kiel, 'Introduction' in L. Douglas Kiel and Euel Elliot, eds, *Chaos Theory in the Social Sciences: Foundations and Applications*, University of Michigan Press, Ann Arbor, 1996, p. 1.
[78] Irreversibility is central to self-organisation and 'one that has an immense constructive importance', Prigogine and Stengers, *Order Out of Chaos*,, pp. 8, 125. Ideas pursued at length by Rosenau, for example, see Rosenau, *Turbulence in World Politics,* esp. ch. 7.
[79] See Prigogine and Stengers, *Order Out of Chaos*, p. 300.
[80] George S. Percivall, 'Application of Complexity Theories to Evolutionary System Development', Francis Heylighen, Johan Bollen and Alexander Riegler, eds, *The Evolution of Complexity: The Violet Book of Einstein meets Magritte*, Kluwer Academic Publishers, Dordrecht, 1999, p. 333.
[81] Ulrich Witt, 'Self-organization and Economics – What is New?', *Structural Change and Economic Dynamics*, vol. 8, 1997, p. 490.

points of attraction are driven and informed by feedback processes, the concept of sensitivity to initial conditions is introduced and it is argued that this is a fundamental, although often exaggerated component, for those that seek to identify the underlying fundamentals of complexity theory.

Sensitivity to Initial Conditions[82]

Old proverbs often take the obvious and present it as wisdom. In introducing the accuracy of weather prediction, Becker and Dörfler recite one such proverb from their own county of Germany. By all accounts German farmers appear (or were) fond of suggesting that 'when the cock crows on the dung heap, the weather will either change or stay as it is'. As far as weather prediction goes it does not come much better than 100 per cent. However, if the rule is changed to state that the weather tomorrow will be the same as the weather today, then the success rate drops down to about 60 per cent. In between these two extremes, current weather forecasting, which utilises an abundance of modern technologies including vast banks of supercomputers, international measuring networks and satellites, stands at no more than 80 per cent.[83] Midway through the twentieth century, there existed an enthusiasm for the possibility of serious long-range forecasting. In a wonderful example of a Kuhnian style defence of a dominant paradigm, when attempting to model weather behaviour, using traditional linear techniques, if the method failed it was thought to be a case of either insufficient data or that the actual linear method being used was inadequate. The question of non-linearity simply did not arise.[84]

Meteorologist Edward Lorenz first established himself in this environment, but later in his career stumbled across anomalies that defied simple linear explanation. From these initial experiments emerged his now widely recognised paper 'Deterministic Nonperiodic flow', arguing that weather prediction (due to the

[82] For many it is considered to be the 'signature of chaos', Johnson, 'Example of Chaotic Dynamics', pp. 259-60. Also known as sensitive dependence to initial conditions.
[83] Becker and Dörfler, *Dynamical Systems and Fractals*, p. 3.
[84] Aubin and Dalmedico, 'History of Dynamical Systems', p. 29.

'nonperiodic flow') into the 'distant future is impossible'.[85] This phenomena was to become known as sensitivity to initial conditions – a mainstay of both chaos and complexity theory. At its simplest it can be understood as emphasising the power of small events.[86] This means that potential outcomes can be substantially different with only the slightest changes of to the initial conditions. However, for the less scientific minded, it was to become known as the butterfly effect. The basic premise of Lorenz's butterfly is that the disturbances from a butterfly flapping its wings in the Amazon could possibly, through a path of multiple intermediaries, give rise to a tornado in Texas.[87] Its acceptance into common parlance illustrates the power of a scientific analogy as a means of describing the physical and social world. By way of its name, and the deceptive simplicity of an idea that defied scientific certainty, it had seemingly captured the popular imagination.

However, credit for this must first go to Poincaré who noted the existence of chaotic phenomena within dynamical systems in the late nineteenth century.[88] Essentially, Lorenz discovered the 'geometric growth of small errors that Poincaré had theoretically predicted for errors in the three-body problem of planetary motion'.[89] The attractor that emerged on Lorenz's computer screen has had 'a much greater suggestive value than Poincaré's purely verbal – and somewhat confusing – descriptions'.[90] Hence, 'the term "butterfly effect" entered our language as a graphic metaphor for Poincaré's fortuitous phenomenon'.[91] Figure 1, which resembles a butterfly's wings, and Figure 2 show the 'strange' attractor

[85] Edward N. Lorenz, 'Deterministic Nonperiodic flow', *Journal of the Atmospheric Sciences*, vol. 20, no. 1, 1963, p. 141.
[86] Rosenau, 'Many Damn Things Simultaneously', pp. 86-7.
[87] Locating the first usage and development of the term butterfly effect is no easy task. Lorenz originally used a seagull analogy. The idea of butterfly as a trigger, and the introduction of Brazil, Texas and a tornado, is attributed to Philip Merilees, the convenor of Lorenz's session at the American Association for the Advancement of Science meeting for 1972, who came up with the analogy in Lorenz's absence when asked to create interesting titles for the session. There still remains contention that the term may have originated earlier, from the work of Joseph Smagorinsky, whom both Lorenz and Merilees had read. The introduction of the word 'effect' is equally contested, and this is not even to mention the even earlier analogy of the grasshopper effect. Robert C. Hilborn, 'Sea Gulls, Butterflies, and Grasshoppers: A Brief History of the Butterfly Effect in Nonlinear Dynamics', *American Journal of Physics*, vol. 72, no. 4 pp. 425-7.
[88] See Chapter Two.
[89] Alwyn Scott, 'Reductionism Revisited', *Journal of Consciousness Studies*, vol. 11, no. 2, 2004, p. 53. See also Chapter Two.
[90] Aubin and Dalmedico, 'History of Dynamical Systems', p. 30.
[91] Scott, 'Reductionism Revisited' p. 53.

that so defined chaos and from which concepts of positive feedback, non-linearity and far-from-equilibrium systems within complexity theory have been supported

Figure 9 *(left)*: The 'Classic' Lorenz Attractor: 'Projection on the x-y plane'.[92]

NOTE:
This figure is included on page 162 of the print copy of the thesis held in the University of Adelaide Library.

NOTE:
This figure is included on page 162 of the print copy of the thesis held in the University of Adelaide Library.

Figure 10 *(right)*: The Lorenz Attractor in three dimensions.[93]

Lorenz recognised, in regard to weather forecasting, the 'eventual necessity for any bounded system of finite dimensionality to come arbitrarily close to acquiring a state which it has previously assumed'.[94] The graphic depictions of the attractor above illustrated that when tracked through phase space a pattern, a basin of attraction, is readily observable. Yet it never exactly repeats whilst bifurcating from one axis to another. Utilising Lorenz's findings, it can be said that stability and quasi-periodic phenomena may well occur, but such stability is not based on the observance of analogues, but instead on *assumed* similarities.[95] This connects again to the idea that the Newtonian paradigm, in the Kuhnian sense, establishes

---

92 'Chaos and Fractals', Department of Physics and Astronomy, Johns Hopkins University. http://www.pha.jhu.edu/~ldb/seminar/attractors.html, accessed 12/10/ 07. Under the two dimensional portrait it states: 'The Lorenz attractor is an example of a strange attractor. Strange attractors are unique from other phase space attractors in that one does not know exactly where on the attractor the system will be. Two points on the attractor that are near each other at one time will be arbitrarily far apart at later times. The only restriction is that the state of system remain on the attractor. Strange attractors are also unique in that they never close on themselves — the motion of the system never repeats (non-periodic). The motion we are describing on these strange attractors is what we mean by chaotic behavior.' ibid.

93 ibid.

94 Lorenz, 'Deterministic Nonperiodic Flow', p. 141.

95 ibid. The difficulty with social and political systems is that dimensionality is not based on immutable boundaries.

research agendas that persistently strive 'to bring theory and fact into closer agreement'.[96] Moreover, the Lorenz Attractor displays how 'an infinite number of layers of phase space are contained within a finite volume of phase space'.[97] The exact same point is never realised, but a basin of attraction is achieved:

> the attractor itself is bounded to a particular region of space, because chaotic systems are characterised by growth and a decay factor. Each trip around the attractor is called an orbit. Two orbits that are close together initially will rapidly diverge, even if they are extremely close at the outset. But they will not fly away from each other indefinitely. Eventually, as each orbit reaches the outer bound of the attractor, it returns towards the center. The divergent points will come close together again, although many orbits may be needed to do so. This is a property of sensitive dependence on initial conditions.[98]

Accepting that non-linear systems are sensitive to initial conditions allows, at one level, the concession that 'each decision has the character of an amplification'.[99] This is one of the basic principles derived from chaos theory, and, importantly, it is this type of amplification that can instigate novel fluctuations that drive diverse and curious branching and bifurcations within a non-linear system.[100] In a traditional Newtonian model it has been argued that it is possible to predict the final state from the initial conditions,[101] yet by introducing the notion of sensitivity to initial conditions the nature of causality changes. Every sequence, iteration or event is informed by what has happened previously. However, it is not the case the every link in the causal chain adds up or equals a particular result. Adding or removing an event or information, irrespective of size or perceived importance, or starting the causal chain at a different point, can have dramatic and unpredictable

---

[96] Kuhn, *Structure of Scientific Revolutions*, p. 80.
[97] Gribbin, *Deep Simplicity*, p. 101.
[98] Peters, *Fractal Market Analysis*, p. 240.
[99] Peitgen and Richter, *The Beauty of Fractals,* p. 1.
[100] Gell-Mann, *Quark and the Jaguar*, p. 164.
[101] West and Deering, *Lure of Modern Science*, p. 20. Waldrop, echoing the Heisenberg principle, notes that 'We can't help but disturb the universe', Waldrop, *Complexity*, p. 65. However, when Lorenz's findings relating to sensitivity to initial conditions are incorporated, Heisenberg's position on determinism can be portrayed as incomplete. Lorenz illustrated that not only is the premise misleading, as Heisenberg contends (see Chapter Two), but so to is the conclusion. 'Chaos' or 'randomness' is not excluded because of 'natural laws' or any form of determinism. It is the assumption of equivalency between determinism and predictability that is in need of being discarded. Peitgen, et al, *Chaos and Fractals*, p. 14.

consequences. Of course, it is possible that little change may register, as *initial* knowledge can be quickly mitigated in a high information environment.[102] The earth's weather system has an innumerable number of variables that affect, interact, feedback, amplify, buffer and dampen occurrences that play a role in determining the weather (therefore, to think that one is able to isolate it to a single butterfly borders on the ridiculous).[103] Yet the relevant point is that as any complex process unfolds, more and new information is both generated and then retained meaning a multiplicity of possible events,[104] undermining the idea of projected linear outcomes. Through this, sensitivity to initial conditions places 'a very naïve conception of causality into serious question – that is, the conception where the effect is believed to be proportional to the cause.'[105] Instead, locales of attraction, not notions of additive causality, should form the basis of any generalisation. This conjecture buttresses the presupposition that a complex system can neither exist in a chaotic or anarchic state, but nor can it exist in a system that is too ordered or too stagnant. What becomes critical is how and where a system is 'poised'.

Phase Transitions

As has already been seen, complexity theorists conceptualise and map systems according to the phase space they occupy. More interestingly, complex systems are considered to be on the edge of chaos, or, specifically, they lie in the 'phase space' between order and chaos.[106] The research that has been undertaken, primarily using computer simulations, has found that systems that bear the hallmarks of complex adaptive systems only arise at the critical juncture between order, when activity becomes halting or fixed, and chaotic, when, like television

[102] Further, if the adaptation pressures found in complex systems are included, the butterfly effect can be seen to be mitigated over time as opposed to amplified as can occur in purely chaotic systems. Kauffman, *At Home in the Universe*, p. 91.
[103] Gribbin, *Deep Simplicity*, p. 57. Including but also irrespective of those factors it is equally important to remember that any butterfly effect decreases exponentially over time, otherwise every butterfly may well cause a tornado. Massimo Pigliucci, 'Chaos and Complexity', *Skeptic*, vol. 8, no. 3, Summer 2000, p. 63.
[104] Peitgen and Richter, *The Beauty of Fractals,* p. 2. Prigogine and Stengers also note that initial conditions become forgotten. Prigogine and Stengers, *Order Out of Chaos*, pp. 122-8.
[105] Holm, 'Does Chaos Theory have major implications for Philosophy of Medicine', pp. 79-80.
[106] Waldrop, *Complexity*, p. 234.

'snow', it is too indeterminate for any discernable pattern to be recognised.[107] Systems can adapt, it is argued, if they are situated in a phase space that borders on being either too chaotic or too ordered, with natural selection playing a role in determining the viability and longevity of a particular system (or agents within a system). In either instance an optimal fitness or equilibrium is not necessarily attained. Major change in a 'nonlinear dissipative complex' system, which is the argument that is made of the international system in the final two chapters, occurs when 'old structures become unstable' and are broken down 'by changing control parameters'.[108]

To explain in more detail, the conceptual basis of phase transitions originally stemmed from the work of mathematician, and significant Manhattan project contributor, John von Neumann's development of the mathematical concept of cellular automata. Steven Wolfram picked up from where von Neumann left off, performing extensive computer simulations in an effort to determine the 'dynamics of complex behaviour in cellular automata'.[109] Cellular automata are essentially programs for generating patterns on a computer screen according to prescribed rules. The novelty of the experimentation is that complex patterns can emerge from very simple underlying rules.[110] Each cell is governed (via an algorithm) by a 'local transition rule'; that is, it interacts only within its local environment[111] whilst being contained or bounded by the 'rules' of the program. In a nutshell, cellular automata are best described as 'formal models of self producing organisms', and with the development of more and more powerful computers, cellular automata have been used increasingly across various disciplines in order to model emergent behaviour.[112] There are issues associated

[107] ibid. pp. 233-234.
[108] Mainzer, *Thinking in Complexity*, p. 4.
[109] Lansing, 'Complex Adaptive Systems', pp. 190-1. See also Wolfram, *A New Kind Of Science*, passim. Stanislaw Ulam was also involved in their development. Dave Burraston and Andrew Martin 'Digital Behaviors and Generative Music', Leonardo Electronic Almanac vol. 14 no. 7-8, 2006, http://leoalmanac.org/journal/Vol_14/lea_v14_n07-08/dburastonamartin.asp, accessed 07/07/07.
[110] Morel and Ramanujam, 'Through the Looking Glass', p. 280.
[111] Burraston and Martin 'Digital Behaviors and Generative Music', URL.
[112] Palash Sarkar, 'A Brief History of Cellular Automata', *ACM Computing Surveys*, vol. 32, no. 1, 2000, p. 80.

with rules-based models of this kind,[113] but with respect to the rise of complexity theory it was adaptation of this new research tool by the Santa Fe Institute's Christopher Langton, with parallels drawn with Stuart Kauffmann's work, that produced results that had a defining impact.[114]

Langton's continuation and programming of Wolfram's four cellular automata rule types has led to the greatest fruition in terms of understanding the significance of phase transitions upon dynamical systems. Utilising the four rule types, Langton demonstrated that Class I were 'doomsday' rules and die within two moves and are considered dead, Class II are marginally better, and, after the planting of the initial 'seed', quickly form static, pulsating blobs; or in others words they appear highly ordered. Class III are found at the other extreme; where they are frenetic and *chaotic*, with no order or predictability, no discernible pattern can be made from this class of automata.[115] Class IV prove to be the most interesting, as they produce complex structures that split, grow and mutate.[116] The Class IV behaviour occurs rarely, and the point between order and chaos is considered to be a phase transition, which is very much where the notion of 'edge of chaos' emerged.[117] Figure 3 shows some of the conclusions drawn from his findings:

[113] See the introduction.

[114] See Christopher G., Langton, 'Self-reproduction in cellular automata', *Physica D: Nonlinear Phenomena*, vol. 10, no. 1-2, 1984, pp. 135-44.

[115] Indeed, Kauffman, in respect to his own research (and it should be remembered that he has worked closely and alongside Christopher Langdon at the Santa Fe Institute), states that 'in the chaotic regime, similar initial states tend to become progressively more dissimilar, and hence to *diverge* further and further apart in state space, as it passes along its trajectory', Kauffman, *At Home in the Universe*, p. 91.

[116] For a good overview see: Waldrop, *Complexity*, esp. pp.224-235, 292-294. See also Alex Lancaster, *Life at the Edge of Chaos*, http://www.santafe.edu/~alex/life.html, accessed 21/3/01. A little differently, and in the language of the previous section on phase space, when looking at as attractor in phase space which has emerged from mapping the results from the 'long term behaviour of dissipative systems' it has been found that they can be classified in one of four groups. Firstly, there is the 'single stable point', then there is the 'periodic attractor with a fixed period, the third attractor can be characterised as quasi-periodic, and finally the fourth is considered aperiodic and is the so-called chaotic attractor. The qualitative characteristics of the first three attractors in phase space are that of the point, the circle, and the torus (respectively). The fourth, the chaotic attractor, does not appear as one of these shapes and was hence coined as a strange attractor. Chatterjee and Yilmaz, 'Chaos, Fractals and Statistics', p. 55.

[117] Burraston and Martin 'Digital Behaviors and Generative Music', URL.

Phase Transitions

Cellular Automata Classes:
I & II ↔ 'IV' ↔ III

Dynamical Systems:
Order ↔ 'Complexity' ↔Chaos

Matter:
Solid ↔ 'Phase Transition' ↔ Fluid

Computation:
Halting ↔ 'Undecidable' ↔ Nonhalting

Life:
Too Static ↔ 'Life/Intelligence' ↔ Too Noisy

Figure 11: Analogies for Phase Transitions[118]

It became apparent to Langton that the fluidity found between order and chaos is an essential component within dynamical systems, so that they may properly function. It is not difficult to extend his ideas to include concepts like society, life and, of course, international politics. On life itself, it is argued by some adherents that it can be considered not only to occur, but also in terms of its very existence and creation, to be only possible within a phase transitional space that is neither too ordered nor too chaotic.[119] Burraston and Martin provide a visual representation of the space-time plots of each of the one-dimensional cellular automata below:[120]

---

[118] Waldrop, *Complexity*. pp,233-234. Life as a Class IV phase transition was put forward as a possible hypothesis.
[119] For a good overview see: Waldrop, *Complexity*, especially pp. 224-235, 292-294. For correlations see also Kauffman, *Origins of Order*, pp. 219-21. 'The evocative phrase that points to this working hypothesis is this: life exists at the edge of chaos. Borrowing a metaphor from physics, life may exist near a kind of phase transition', Kauffman, *At Home in the Universe*, p. 26. See also Fritjof Capra, 'Complexity and Life', *Theory, Culture and Society*, vol. 22, no. 5, 2005, pp. 33-44.
[120] Burraston and Martin 'Digital Behaviors and Generative Music', URL. It is important to note that cellular automata can have many dimensions and are contingent upon both space and time.

NOTE:
This figure is included on page 168 of the print copy of the thesis held in the University of Adelaide Library.

Figure 12: 'Langton's schematic of [cellular automata] rule space and example space-time plots of their behaviour'[121]

The visualisation is powerful, as the image, sharing a similarity to the initial impact of fractals, depicts the emergence of complex behaviour within a (constructed) system. Characterising complex phenomena in this phase transitional space intrinsically depicts non-linear accounts of emergent systems as computationally irreducible (to borrow a term from Stephen Wolfram),[122] on the one hand, and, on the other, it provides a powerful explanatory tool for those systems that move too close to either the ordered or chaotic ends of the space. Additionally, this research ties into assumptions, at an analogous level, that began in the early days of chaos research. The latter was suggesting that complex systems, ranging from national defence through to the global environment, 'switch between phases of order and disorder',[123] concepts that link with immediacy to the theory of self-organisation. Moreover, it supports the notion that to remain viable, order in a complex system will *always* arise. The manner in which

[121] ibid.
[122] Wolfram, *New Kind of* Science, p. 750.
[123] Becker and Dörfler, *Dynamical Systems and Fractals*, p. 242.

complex systems attract to order is an autopoetic process.[124] In essence, self-organisation should be understood as a permanent and continually occurring feature.

Self-Organisation

In the spirit of Jean Piaget, 'organization is not only a feature of the world (social and/or natural), but also of our *thinking about the world*'.[125] Of course, there have long existed spontaneous order traditions, most notably the Scottish Enlightenment.[126] However, as a field of scientific study that recognises recent movements in the physical and biological sciences, self-organisation has become a benchmark of the 'holistic' project that defines the complexity theory-inspired approach. In particular, it assists in providing an 'equally rigorous, scientific perspective compared with reductionist scientific methods'.[127] The work has been pioneered by Kauffman, who defines his theory of self-organisations as:

> an attempt to understand how complicated rules or spatially complex systems with many interacting components produce complex, but organized and patterned behaviors and to explain the apparent paradox of how organized large-scale structures function when their constituent elements are 'swimming in a sea of chaos'.[128]

---

[124] On Autopoises see Luhmann, *Social Systems*, pp. 483-4. What Luhmann is dealing with is 'social complexity as opposed to complexity theory, although similarities are certainly present. See Stewart, 'Complexity Theories, Social Theories', pp. 336-8. See also John A. Smith and Chris Jenks, *Qualitative Complexity: Ecology Cognitive Process and the Re-Emergence of Structure in Post Humanist Social Theory*, Routledge, London, 2006, pp. 6-8.

[125] Hatch and Tsoukas, 'Complex Thinking About Organizational Complexity', p. 4.

[126] Alexander Wendt has similarly noted this correlation See Wendt, 'Why a World State is Inevitable', pp. 492, 498.

[127] Peter V. Coveney, 'Self-Organization and Complexity: a New Age for Theory, Computation and Experiment', *Philosophical transactions of The Royal Society,* vol. 361, No. 1807, 2003 p. 1059. Borrowing from physics, Lee Smolin noted that the chaotic phenomena of fractals can also, if only analogously, be linked to the 'mechanisms of self-organization' that under pin complexity theory. Here the concept can be extended 'from the largest scales to the smallest,' helping to explain 'both the properties of the elementary particles and the history and structure of the whole universe.' Lee Smolin, 'A Theory of the Whole Universe', '*The Third Culture: Beyond the Scientific Revolution*, Simon & Schuster, 1995, http://www.edge.org/documents/ThirdCulture/z-Ch.17.html, accessed 17/02/2006.

[128] Mathews, et al., 'Why Study the Complexity Sciences', p. 447.

Obvious links quickly emerge with Christopher Langton's work on phase transitions. This has not gone unnoticed, and, increasingly, there are suggestions that complexity holds important insights into significant issues ranging from the 'large-scale structure of the Universe, the origin and evolution of life on Earth … consciousness, intelligence and language'.[129] At the social level, self-organisation represents complex dialectical relationships that focus on information flows between the social and the individual, representing a dynamic that facilitates the constant 're-creation' of society.[130] As a preliminary definition, the following is appropriate:

> *Complexity* is the study of the behaviour of large collections of such simple, interacting units, endowed with the potential to evolve with time. The complex phenomena that emerge from the dynamical behaviour of these interacting units are referred to as *self-organizing*. More technically, my definition of self-organization … is the spontaneous emergence of non-equilibrium structural organization on a macroscopic level, due to the collective interactions between a large number of (usually simple) microscopic objects. Such structural organization may be of a spatial, temporal or spatio-temporal nature, and is thus an *emergent* property.[131]

---

[129] Coveney, 'Self-Organization and Complexity', p. 1059. Simon Levin also posits that the 'emergence of global regularity from local rules has been a universal theme in the physical and biological sciences, in the social sciences, in linguistics, and elsewhere. The basic theorems of dynamical systems theory investigate the circumstances in which initial conditions and dynamical rules are sufficient to specify unique solutions, and in which bifurcations occur; in the latter case, the choice of which patterns and dynamics emerge after bifurcation may depend on conditions not included in the description of the system'. Simon A. Levin, 'Self-Organization and the Emergence of Complexity in Ecological Systems', *BioScience*, vol. 55, no. 12, 2005, p. 1078.

[130] Christian Fuchs, 'Social Information and Self-Organisation', in Robert Trappl, ed., *Cybernetics and Systems 2002*, vol. 1, Vienna, 2002, pp. 225-230, *passim.* Harvey notes that 'the very attainment of social system adaptation and momentary internal equilibrium, the stage is set for system negation and development. This ongoing dialectical motion forms the kernel of what chaos theoreticians have long called far-from-equilibrium systems.' Harvey, 'Agency and Community', p. 179. On the idea of thesis and antithesis pushing and driving particular cultural groups and their efforts at state creation and maintenance see, for a rudimentary account Chapter Four of Walter C. Clemens Jr., *The Baltic Transformed: Complexity Theory and European Security*, Rowman & Littlefield, Lanham, 2001.

[131] Coveney, 'Self-Organization and Complexity', p. 1058. In his insightful exploration and critique of Kauffmann's argument, Richardson captures the essence of self-organisation when he states that it 'allows us to describe the features such systems will manifest, and their natural dynamics. This is done without predicting, or knowing, or caring about, the specific organization of the system. We abstract from the organization, and then describe the macroscopic phenomena statistically, as the expected features of complex systems', Robert C. Richardson, 'Complexity, Self-Organization and Selection' *Biology and Philosophy*, vol. 16, no. , 2001, p. 671.

Self-organisation can be understood as a 'dynamic process by which under its own dynamics, a system spontaneously gets increasingly more organized'.[132] Kauffman's central argument rests on the notion that spontaneous order that would, if the course of history were to be replayed, push an ordered world, however different, into existence.[133] Effectively, 'a class of open thermodynamic systems' emerges and 'the spontaneous dynamics drive the system into an infinitesimal corner of its state space and hold it there, quivering for an eternity'.[134] This is where the process becomes married to Langton's phase transitions to produce Kauffman's concept of 'order for free'.[135] This order is 'vast and generative' and 'arises naturally' with its 'robust and emergent' nature leading to a kind of collective crystallization of spontaneous structure.'[136] According to Kauffman, 'the patterns of life's bursts and burials are caused by internal processes endogenous and natural', with many of these changes occurring as 'avalanches', both large and small.[137] With respect to biological evolution, it has contributed to explaining how evolution accelerated, with a significant proportion of it occurring during the 'last 15% of earth's history'. [138]

However, it is important to reinforce the point that the role of natural selection is not removed, replaced or relegated. *Non-linear* and *non-reductionist* evolutionary approaches continue to hold influence, are arguably complimentary, and are not incommensurable with theories of self-organisation. In respect to selection, Kauffman stressed that in 'sufficiently complex systems, selection cannot avoid the order exhibited by most members of the ensemble', meaning that the order that arose did so 'not because of selection but despite it'.[139] Kauffman has

[132] Morel and Ramanujam, 'Through the Looking Glass of Complexity', p. 282.
[133] Kauffman, *At Home in the Universe*, pp. 7-8. He is quick to point out that outcomes may diverge quite significantly, no *homo sapiens* for instance.
[134] ibid., p. 83.
[135] ibid.
[136] ibid., pp. 25, 18.
[137] ibid., p. 15. An idea that he also feels comfortable relating to cultural systems. ibid.
[138] Morel and Ramanujam, 'Through the Looking Glass of Complexity', p. 282.
[139] Kauffman, *Origins of Order*, p. 16. See also Lansing, 'Complex Adaptive Systems', p. 190. Drawing on W. Ross Ashby's work they examined brain design Kauffman argues than in a 'system-cum-environment' that is deterministic the system will 'if released from any initial state, the system will flow to an attractor and

consistently argued that self-organisation is a reply to Darwinian evolutionary theory (and, significantly, that it also represents an 'antichaos' sentiment).[140] Essentially, the role of natural selection should be understood as a major contributing factor and explanatory tool for understanding evolution, but it cannot, insists Kauffman, be thought of as to the singular means of understanding the emergence and diversity of life. Using ecosystems as an example, the relationship between the two concepts is well put by Simon Levin who states that:

> Ecosystems, however one defines them, self-assemble from components shaped by evolution, and self-organize as those components reproduce and express phenotypic plasticity [the ability to change in response to the environment]. The evolution of the components is driven by the relative fitness of those components, not by the fitness of the system as a whole. But the truth is between the extremes. To recognize that ecosystems are not selected as wholes does not mean that one must view all selection in terms of selfish genes (Dawkins 1976). Selection can act at intermediate levels, forging mutualisms, coalitions, and even multicellular assemblages.[141]

What is evident is the anti-reductionist sentiment of this account of selection on the one hand, whilst not, on the other, removing the role of component parts by suggesting that they exist only as an element of the whole. In coming to terms with this, Kauffman supposes 'that a *subset* of the organism's internal variables constitutes *essential variables*, which must be maintained within certain bounds'.[142] He extends this idea of subsets to whole ecosystems, implicitly acknowledging the nested nature of multiple agents that do not aggregate into a single living entity of biological proportions. Using his notion of 'packets', he reconciles that 'real ecosystems are not totally connected', as in any ecosystem every individual

---

stay there'. Kauffman, *Origins of Order*, p. 210. And, moreover, 'if selection is powerful enough [which it isn't in an open system] then self-organization plays no part', ibid., p. 173.

[140] Mathews, et al., 'Why Study the Complexity Sciences', p. 448.

[141] Levin, 'Self-Organization and the Emergence of Complexity', p. 1076. Indeed, as revealed by their first proposition Morel and Ramanujam push that the 'evolutionary dynamics underlying organizational changes is a mix of randomness and reaction to external and internal pressures. Although it is not driven by "fitness," it is successful only if it leads to an increase of fitness.' Morel and Ramanujam, 'Through the Looking Glass of Complexity', p. 284.

[142] Kauffman, *Origins of Order*, p. 210.

species only 'interacts with a subset of the total number of other species' and from these interactions a web-like structure can be said to develop.[143] Here the same can be said of an international society, with multiple worlds or scapes existing. In such an environment the state can have multiple meanings and functions, with the interactions unable to be contained by a universal understanding. This leads into a generally accepted principle of complexity theory that emerges from the study of self-organisation, the notion that information continues to increase, resulting in the system, or interrelated systems, driving toward greater and greater complexity.

Self-Organised Critically

Held apart but quite obviously sharing similarities to Kauffman's theory of self-organisation, is the clumsily named theory of self-organised critically. As is the case with many new theories that seek to explain a lot, it arrived with much fanfare, not least because its creator Per Bak immodestly claimed to have revealed 'how nature works'.[144] The theory of self-organised critically experiments using a pile of sand that is steadily added to and, once the pile has reached a critical point, it will always remain in a state that is 'close to critical'. Adding an extra grain of sand may cause a major avalanche, a number of minor ones or nothing at all.[145] Moreover, once triggered a chain reaction of avalanches will only halt once stability has returned to the entire structure but, and this is the vital element, the size and range of what occurs bears no direct relationship to the size of the 'original' perturbation; novelty and unpredictability ensue.[146] In short, the pile of sand is:

[143] ibid., p. 255. Reflecting this '…avalanches or perturbations, made up of "packets" of coevolutionary change and having characteristic relation between size and scale and frequency, may propagate through an ecosystem'. ibid., pp. 255-6.

[144] Roman Frigg, 'Self-Organised Critically – What it is and What it isn't', *Studies in History and the Philosophy of Science*, vol. 34, no. 3, 2003, p. 621.

[145] Gribbin, *Deep Simplicity*, p. 159.

[146] Frigg, 'Self-Organised Critically', p. 617. It should be noted that 'the critical state is an attractor of the system'. ibid. Self-organised critically also exhibits the scale invariance of time scales similar to that found in fractals. ibid., p. 618. And, of course, sharing the scaling effects found within fractals. See also Per Bak, Chao Tang and Kurt Wiesenfeld, 'Self-Organized Critically', *Physical Review A*, vol. 38, no. 1, 1988, pp. 364-5.

> self-organised because the pattern occurs spontaneously, there is no outside agent or 'invisible hand' who impose order. Hence, what has happened is that the addition of sand has turned the pile from a stable system in which the dynamics of individual grains is local, into a critical system in which the emergent dynamics is global.[147]

More so, self-organised critically describes the thresholds in which certain systems are driven to, and the 'meta-stable equilibria' that are formed, and are punctured, by sudden ruptures that show scale invariance similar to that of fractals.[148] In arriving at these critical points of stability, Bak recognised that the structural integrity of a sand pile occurred at the edge of chaos.[149] For Bak et al., this critical threshold is both an attractor and a 'generic property of naturally occurring dynamical systems'.[150] This is where the links to Kauffman appear, with suggestions that many physical and natural systems move naturally towards a critical point balanced between disorder and order. Further, this state occurs without necessitating explicit or detailed specifications from the initial starting conditions.[151] As Kaufman himself explains:

> Sandpiles, self-organized critically, and the edge of chaos. … the very nature of coevolution is to attain this edge of chaos, a web of compromises where each species prospers as well as possible but where none can be sure if its best next step will set off a trickle or a landslide. In this precarious world, avalanches, small and large, sweep the system relentlessly.[152]

---

[147] ibid., p. 616. Basically, when looking at the pile of sand it needs to done so in a 'global' sense. Fred Guterl, 'Riddles in the Sand', *Discover*, vol. 17, November, 1996, p. 108. It is not difficult to imagine the analogies that have been made across a variety of disciplines and phenomena.

[148] These ruptures are prone to scaling phenomena that appear to be very much influenced by power laws. Lars-Erik Cederman, 'Modeling the Size of Wars: From Billiard Balls to Sandpiles', *American Political Science Review*, vol. 97, no. 1, 2003, p. 137. 'Power laws tell us that the size of an event is inversely proportional to its frequency', ibid, p. 135. By way of explanation power laws (1/f) share the invariance of fractals – hence scaling can be seen to occur. That is, irrespective of the scale a similar distribution will occur.

[149] Gribbin, *Deep Simplicity*, p. 158.

[150] Bak, et al., 'Self-Organized Critically', p. 365.

[151] Mathews, et al., 'Why Study the Complexity Sciences', p. 446.

[152] Kauffman, *At Home in the Universe*, p. 29. See also Kauffman, *Origins of Order*, pp. 255-6.

Yet despite the excitement generated by it as a theory, self-organised critically cannot explain all things that are dynamical, evolve and become complex, much in the same way that the geometry of nature is not singularly defined by fractal geometry.[153] The lack of interaction and learnt behaviour between grains of sand essentially limits its usefulness – even as an abstraction. Bak is aware that his sand pile model is a simplification, yet he still draws strong correlations between his theory and the meta-stable phenomena that occur in natural ecosystems, where 'different species "support" each other in a way that cannot be understood by studying the individual constituents in isolation'.[154] The realisation that a critical balance self-organises is a vital step. However, within this theory, the interacting agents, whether they are grains of sands, computer-generated cells, or entire species, are locked into their prescribed functions. This is fine for grains of sand, but it is less helpful when dealing with living systems that are made up of agents that have the capacity to learn, adapt and change. In short it diminishes both evolution and emergent behaviour. For example, in drawing correlations to ecosystems, as a theory it can be said to miss:

> the essential nature of the biosphere as a complex adaptive system in which modularity and heterogeneity emerge and play crucial roles in mediating robustness. How do modularity and heterogeneity arise in this context, how are they maintained, and what are the implications for maintaining the robustness of ecosystems and the biosphere? To address these questions, we need to recognize the full complexity of ecological systems, and the interplay among processes at diverse scales of space, time, and complexity. Evolutionary processes at smaller scales, including the coevolution of tightly interacting species, give rise to emergent macroscopic patterns at higher levels of organization.[155]

Bak's theory of self-organised critically made important advances into the study of dynamical systems, but the relationship between agent and structure was still not

[153] Frigg, 'Self-Organised Critically', p. 614.
[154] Bak, et al, 'Self-Organized Critically', p. 364. They continue, underscoring the centrality of self-organised critically to the development of complexity theory, 'The same interdependence of species also makes ecosystems very susceptible to small changes or "noise." However, the system cannot be too sensitive since then it could not have evolved into its present state in the first place. Owing to this balance we may say that such a system is "critical."'. ibid., p. 365.
[155] Levin, 'Self-Organization and the Emergence of Complexity', p. 1076.

being properly problematised. Yet, at the very least, as did research into dissipative systems, the approach supported the importance of studying non-equilibrium systems.[156] Moreover, systems of this nature must be open, meaning that energy must come from 'outside'.[157] This acknowledges that the second 'law' of thermodynamics has a role to play when unravelling complex systems. More commonly referred to as entropy, it runs counter to notions of self-organisation. Indeed, self-organisation can only occur if entropy is successfully minimised or reduced,[158] with self-organisation theory helping to explain as to why there is something instead of nothing.[159] Therefore, entropy is an essential component that must be discussed when arguing the primacy of self-organising nature of far-from-equilibrium systems that are complex and have the ability to adapt to changing environs.

Entropy

Briefly, entropy concerns the amount of order in a system and, in particular, the amount of energy that is expended to maintain a system.[160] Effectively it relates to heat death. Entropy, as understood as the second law of thermodynamics, refers to closed equilibrium systems. The nature of these systems is that they are 'closed to the exchange of matter and energy with their environment' and that disorder (that is, entropy) unavoidably increases (i.e. gases mix but do not spontaneously unmix).[161] The result is that 'order – the most unlikely of the arrangements – tends to disappear'.[162] Therefore, a system that resides in a state that is near equilibrium will produce minimal entropy and will be far more likely to respond to

[156] See Bak, et al, 'Self-Organized Critically', p. 373.
[157] Gribbin, *Deep Simplicity*, p. 158.
[158] John Collier, 'Self-organization, Individuation and Identity', *Revue Internationale de Philosophie*, vol. 59, no. 5, 2004, pp. 153-4.
[159] Waldrop, *Complexity*, p. 10. See also Cohen and Stewart, *Collapse of Chaos*, pp. 251-2.
[160] Gribbin, *Deep Simplicity*, p. 25. See also, and a slightly differing viewpoint, Cohen and Stewart, *Collapse of Chaos*, pp. 248-53.
[161] Kauffman, *At Home in the Universe*, p. 9.
[162] ibid. Prigogine and Stengers place the 'birth of the "science of complexity"' to 1811 when Baron Jean Joseph Fourier … won the prize of the French Academy of Sciences for the propagation of heat in solids'. Moreover, they assert that 'at the peak of its glory the Laplacian dream met with its first setback. A physical theory had been created that was every bit as mathematically rigorous as the mechanical laws of motion but that remained completely alien to the Newtonian world. From this time on mathematics, physics, and Newtonian science ceased to be synonymous.' Prigogine and Stengers, *Order Out of Chaos*, p. 104.

disturbances in a linear fashion.[163] Conversely, the primary feature that best encapsulates a dissipative system is the loss of energy.[164] The result of this is that dissipative structures, which are 'those characterized by high states of energy exchange with the environment', are more open and have considerably more freedom (characterised by instability) than equilibrium- based systems.[165] The consequence of this is that open non-linear dynamical systems will 'not evolve towards its maximum of entropy' and will maintain processes that are described as being far-from-equilibrium.[166] This supports, again, elements of the presuppositions stated at the beginning of the chapter.

Complex systems are in part defined by this interaction between entropy and self-organisation principles. Indeed, it is the adaptive qualities of these systems that help them to maintain, through necessity, their far-from-equilibrium status. Thus, by accepting how non-linear dynamical systems function, accommodating the various building blocks that have been dealt with in the previous sections, it is possible to properly introduce the concept of the complex adaptive system. All too often this is seen as a simple theoretical framework in which the variable could simply be plugged in. Alternatively, it has often attracted attention as a loose metaphor without consideration as to the real impact it offered to the nature of how dynamical systems operate.

Complex Adaptive Systems

The ideas and building blocks that have been discussed above interlock at various points and assist in discussing the space in which a notion of reality interacts and is abstracted into what is commonly accepted and considered to be a 'system'.[167]

---

[163] Gribbin, *Deep Simplicity*, pp. 30, 105.
[164] Peitgen, et al, *Chaos and Fractals*, p. 655. This 'loss' of energy should be viewed as a '*natural process* within the system' Prigogine and Stengers, *Order Out of Chaos*, p. 120.
[165] Mathews, et al., 'Why Study the Complexity Sciences', p. 443.
[166] Morel and Ramanujam, 'Through the Looking Glass of Complexity', p. 282.
[167] Take just some of the Oxford English Dictionaries entries for 'system'. The definitions are representative of both linear and non-linear accounts but the emphases rests on the ideational connectivity in the creation of a whole ('real' or 'imagined'): 'A set or assemblage of things connected, associated, or interdependent, so as to form a complex unity; a whole composed of parts in orderly arrangement according to some scheme or plan; rarely applied to a simple or small assemblage of things'; '*Physics.* A group of bodies moving about

Incorporating these concepts, and the presuppositions that underpin them, allows for a flexible and encompassing idea that challenges linear and reductionist orthodoxies of what a system entails. The approach is built on the admission of the holistic and open nature of a non-linear system, in that:

> When dealing with any nonlinear system, especially a complex one, it is not sufficient to think of the system in terms of parts or aspects identified in advance, then to analyze those parts or aspects separately, and finally to combine those analyses in an attempt to describe the entire system. Such an approach is not, by itself, a successful way to understand the behavior of the system. In this sense there is truth in the old adage that the whole is more than the sum of its parts.[168]

From this, and the work of John Holland (another alumni of the Santa Fe Institute), has developed the concept of the complex adaptive system that has become a touchstone, not only for thinking about complex systems, but stretching to even the most rudimentary and shallow *applications*. Effectively, it has a resonance in metaphor and analogy, whilst ironically, offering a certainty of a pseudo-scientific methodological approach. Yet before taking the criticism further it is important to establish what a complex adaptive system is (beyond the 'common-sense' idea that immediately arises).

First, interactions, which exist in all systems, become the focal point in a complex system, as, significantly, the very idea of structure becomes defined by 'the relationships among the various components of a system'.[169] This can be understood as 'an adaptive network' that exhibits aggregated 'properties that emerge from the local interaction among many agents mutually constituting their

---

one another in space under some particular dynamical law, as the law of gravitation'; 'In various scientific and technical uses: A group, set, or aggregate of things, natural or artificial, forming a connected or complex whole.'; '*Linguistics.* A group of terms, units, or categories, in a paradigmatic relationship to one another.'; 'The set of correlated principles, ideas, or statements belonging to some department of knowledge or belief; a department of knowledge or belief considered as an organized whole; a connected and regularly arranged scheme of the whole of some subject; a comprehensive body of doctrines, conclusions, speculations, or theses.'. Oxford English Dictionary http://dictionary.oed.com, accessed 12/01/08

[168] Gell-Mann, 'The Simple and the Complex', p. 15. See also: Gell-Mann, *Quark and the Jaguar.*

[169] Cilliers, 'What Can We Learn From a Theory of Complexity', p. 32.

own environment'.[170] This epitomises the concept of emergence (see below), but suffice to say at this point, what occurs in complex adaptive systems 'is the emergence of high-level order from low-level interactions among heterogeneous, autonomous agents, each guided by a few simple rules'.[171] Adding to this, three rudimentary properties can be taken as a starting point:[172] that there is a 'diversity and individuality of components'; that those components interact in a localised fashion, and; from those interactions will rise an 'autonomous process' (that is, emergence) that will allow, in the strictest sense, a degree of 'replication or enhancement'.[173] Roy Eidelson offers a not entirely unsatisfactory definition of a complex adaptive system, describing it as:

> a large collection of diverse parts interconnected in a hierarchical manner such that organization persists or grows over time without centralized control. … Through a dynamical, continuously unfolding process, individual units within the system actively (but imperfectly) gather information from neighboring units and from the external environment. … Entirely new properties can also emerge spontaneously and unexpectedly. Configured in this manner, the complex adaptive system is poised for potential change and adaptation either through alteration of its rules, connections, and responses or through modification of the external environment.[174]

The basis for these general ideas is taken from Holland's work on the role of adaptation in the building of order. It was Holland's work that lay the foundations of complex adaptive systems and, in support, he defined seven basics that he felt

---

[170] Cederman, *Emergent Actors in World Politics*, p. 50.

[171] Roger Lewin, Teresa Parker and Birute Regine, 'Complexity Theory and the Organization: Beyond the Metaphor', *Complexity*, vol. 3, no. 4, 1998, p. 36. They also state, hopelessly mimicking previous scientific transference, that 'One of the hopes for [complex adaptive system] theory is that it will open social science to the analytical approaches of physical science.' ibid. Seemingly it has never occurred previously. See also Kevin Dooley, 'A Nominal Definition of Complex Adaptive Systems', *The Chaos Network*, vol. 8, no. 1, 1996, pp. 2-3.

[172] It is important to note that these rules are by no means 'laws' and could, conceivably, be delineated further.

[173] Simon A. Levin, 'Complex Adaptive Systems: Exploring the Known, the Unknown and the Unknowable', *Bulletin of the American Mathematical Society*, vol. 40, no. 1, 2003, p. 4.

[174] Roy J. Eidelson, 'Complex Adaptive Systems in the Behavioral and Social Sciences', *Review of General Psychology*, vol. 1, no. 1, 1997, p. 43.

contributed to the establishment of an emergent whole that was much more than the sum of the parts. Holland's thesis runs as follows.

Aggregation is his first principle, a concept that is regularly used by the human mind in order to categorise understanding: just think of states in the international system. It provides an ease of understanding for that which is familiar and it is a fundamental element for those wishing to construct models.[175] This is a form of reductionism, but not a linear reductionism that seals laws of an additive nature that can be just 'plugged in'. Leaving room to discuss how agents interact within boundaries Holland also introduces the idea of 'meta-agents', which are 'agents at a higher level' that form from the aggregation of many other agents. With some sweeping statements he places ants, immune systems, and gross domestic product into this category.[176] In respect to international relations the state is an obvious social aggregate; how it is imagined is dependent upon the lens through which it is viewed. The lens, of course, is ontologically driven. How aggregation in an international or global setting is understood via the lens of complexity is a fundamental challenge of and for the non-linear turn.[177]

Holland's second 'basic' really is what he calls 'tagging', which can be described as a flag or a banner rallying those of a like mind.[178] When moved to a cultural setting, it does raise questions such as what if there exists more than one flag in an arbitrarily declared community. International norms are an obvious example here.[179] As important is the recognition that this allows for the appreciation of

---

[175] Holland, *Hidden Order*, pp. 10-11.

[176] ibid., pp. 11-12. Holland also argues that 'when agents aggregate, they form extra-agent structures called *boundaries*', see ibid., pp. 135, 117-21.

[177] This is pursued in Chapter Five. On complexity theory representing a fifth debate in IR see Emilian Kavalski, 'The Fifth Debate and the Emergence of Complex International Relations Theory: Notes on the Application of Complexity Theory to the Study of International Life', *Cambridge Review of International Affairs*, Vol. 20, no. 3, 2007,

[178] Holland, *Hidden Order*, pp. 12-13.

[179] For an excellent account of the importance of norms, contradicting neorealist and neoliberal claims, contributing the maintenance of order in international politics see Andrew Hurrell, *On Global Order: Power, Values, and the Constitution of International Society*, Oxford University Press, Oxford, 2007, passim, esp. pp. 12-16, 29-39, 110-17.

separate yet overlapping spaces, where identity recognition becomes a central concern. Holland puts it bluntly, writing that:

> tags are a pervasive feature of a [complex adaptive system] because they facilitate selective interaction. They allow agents to select among agents or objects that would be otherwise be indistinguishable.[180]

However, Holland does ignore a strong cultural element in that tags can change over time. His own model, here, lacks a certain level of adaptability but it can be overcome by incorporating lessons from Kauffmann's theory of self-organisation. The third element is that of non-linearity and he notes how the behaviour of aggregates become increasingly complicated because interaction of a non-linear nature defies prediction by simply averaging or summing the composite parts. Holland then moves onto his fourth basic of 'flows' (he uses the analogy of the 'flow of goods'), and it is simple enough to equate this to networks, connectors or synapses. In this he stresses the role of multiplier and recycling effects that bear a similarity to the role of feedback.[181]

The fifth notion is that of diversity and here the work of Kauffman dovetails nicely. Notions of mimicry and convergence come to the fore as holes or spaces that appear in the system are filled with every new adaptation, allowing 'the possibility for further interactions and niches'.[182] Indeed, an 'adaptive radiation' can be seen to occur at nodes that become well-populated.[183] Returning to international relations, an appreciation for the self-similarity of different aggregates emerges. The ability for states, nations, non-government organisations (NGOs), international institutions and global civil societies to aggregate can be

[180] Holland, *Hidden Order*, p. 14. And, importantly, for social systems: 'More complex organizations begin to emerge when crossover and mutation give rise to conditional adhesion tags', ibid., p. 142.
[181] ibid., pp. 23-6.
[182] ibid., pp. 27-9. Attachment can also occur between agents, see ibid., p. 116. On convergence see also ibid., p. 169. On links with Kauffman, *Origins of Order*, pp. 85-95.
[183] ibid., p. 169.

likened to adaptive practices within these basins of attractions.[184] The nature of such aggregations cannot be predetermined but patterned behaviour will emerge. Here, connections can also be made with Bak's concept of self-organised critically, where a dimensionality exists in respect to the distribution of order and organisation.[185] Critical points will develop. From the interactions a rich and more complex world can emerge but the idea that a single point of eutrophy[186] might develop is incorrect. Points will be reached where bifurcations occur, the results of which cascade, with varying degrees of penetration, through the various 'systems'.

His sixth notion, that of 'internal models', refers to anticipation in complex adaptive systems. If the 'models of interest are interior to the agent, the agent must select patterns in the torrent of input it receives and then must convert these patterns into its internal structure'.[187] Effectively, adaptive agents 'anticipate future consequences' and thus both discover and reinforce rules.[188] Again, for IR theory, self-re-enforcing and self-organising normative consideration spring to mind. Hedley Bull, unaware of such developments, captured the essence of how internal models of behaviour might affect future decision making when he noted that there exist 'the complex of rules' that determine 'what may be called the fundamental or constitutional normative principle of world politics in the present era'.[189] For Bull this represented a society of states. However, as argued above, dramatic shifts can occur, which would result in a reconfiguration of any such rules (the 'fundamentals' would suddenly be less fundamental, or, at least a revised or new set of fundamentals would come into being). Significantly, any

---

[184] It is important to recognise that this does not equate to any level of harmony. Resistance to particular aggregates are just as likely to form. Networks at the micro-level are able to challenge powerful actors, and powerful actors simply cannot control the system. For an introduction as to the manner in which global civil society networks have emerged in response to a dominant neoliberal order (the 'rules') see Graeme Chesters, 'Global Complexity and Global Civil Society', *Voluntas: International Journal of Voluntary and Nonprofit Organizations*, vol. 15, no. 4, 2004, pp. 323- 42.
[185] Bak, et al, 'Self-Organized Critically', pp. 364-5.
[186] See Onuf, *World of Our Making*, p. 154.
[187] Holland, *Hidden Order*, p. 31.
[188] ibid., pp. 85, 89.
[189] Hedley Bull, *The Anarchical Society: A Study of Order in World Politics*, 2nd ed., MacMillan, London, 1995, p. 65.

pressure brought to bear upon systems is a result of the flow of information between structures and agents; in this a duality emerges. A fractal element can be detected here, where there will be an attempt to control the 'flow of energy and information' that cascades through the multiple sub-sets and systems.[190] It would not be difficult to introduce ideas of 'codetermined irreducibility' that draw from structurationist ontological perspectives.[191] For Holland, however, this recognition is purely explanatory, meaning any search for predictors in a societal setting is likely to be unreflective and come, unavoidably, with strong normative and cultural baggage. Bound by Darwinian assumptions, this notion of internal models is seen to deliver a way to connect 'future credit to current actions', allowing evolution to favour 'effective internal models and eliminate ineffective ones'.[192] Holland seems unable to escape from the language of scientific efficiency; in social settings it is not always so clean and neat.

Holland's final element is that of building blocks, which is, effectively, how internal models are constructed to deal with a diverse range of situations.[193] The focus is on recognising the parts of the system, in what he has loosely referred to

[190] Patrick Baker, 'Chaos, Order and Sociological Theory', *Sociological Inquiry*, vo. 63, no. 2, 1993, p. 136. For a counter argument see Peter Stewart, 'Complexity Theories, Social Theory, and the Question of Social Complexity, *Philosophy of the Social Sciences*, vol. 31, no. 3, 2003, p. 331

[191] Alexander Wendt and Raymond Duvall, 'Institutions and International Order' in Ernst-Otto Czempiel and James Rosenau, eds, *Global Changes and Theoretical Challenges: Approaches to World Politics for the 1990s*, Lexington Books, Lexington, 1989, p. 59. Reflected at its strongest in the works of Anthony Giddens and Roy Bhaskar and is bound in the agency structure debate. ibid. Bhaskar's transcendental or critical realism can serve here as it recognises, according to William Jackson, that 'Unlike empirical realism, a transcendental realism can contemplate a stratified reality in which causal powers are "emergent" from the structural relationships between objects… . Individuals by virtue of their positions in society, have powers irreducible to the individual level. Human agents are not wholly bound by structural constraints on their behavior (avoiding a crude structural determinism), and yet society is not made up of an aggregation of isolated, externally related agents. The notion of emergent powers rules out reductionist explanations appealing to only a single level of reality. In a stratified reality, the levels are interdependent, and the desire for a reduction to some fundamental level (social structure, human individuals, material nature, etc.) is misplaced. There are no independent, observable, externally related objects that somehow in themselves posses the power to act. Giddens's '"Structuration" 'refers to the reproductions of social structures through individual agency; structure and agency are a duality, neither has primacy'. William A. Jackson, 'Naturalism in Economics', *Journal of Economic Issues*, vol. 29, no. 3, 1995, pp. 769, 771. On its relevance to examining the global system, see also Urry, 'The Complexities of the Global', pp. 242-3.

[192] Holland, *Hidden Order*, p. 34.

[193] ibid., p. 35. Holland is quite enamoured with the notion of building blocks. For example, see John Holland, *Emergence: From Chaos to Order*, Oxford University Press, Oxford and New York, 1998, esp. pp. 211-18.

as a form creative reductionism.[194] Yet, the reductive tendencies disguise how situations can be 'decomposed'.[195] Holland offers the example of musical notation to illustrate the endless array of possibilities even though there exists 'reduced' and agreed upon building blocks.[196] How musical notation is constructed is reminiscent of strange attractors where infinite yet recognisable behaviour is evident. Yet, the manner in which music is broken down is one thing, but for social agents the recognition of core entities or functions allows agents to not be considered aimlessness or blind to events around them. This means that complex adaptive systems, at a general level, 'exhibit coherence under change, via conditional action and anticipation, and they do so without central direction'.[197] Adaptation and system coherence occur simultaneously.

Holland's principles define the starting points for understanding order in a complex adaptive system that marry neatly with many of the other ideas that have been discussed in this chapter. And with these ideas comes the revelation that order in these types of systems, which includes human social systems, will *always* move towards a point of order. Chaos, or anarchy, is just a part of that process. Further, Holland's ideas are supported by Kauffman's[198] work into self-organisation that was discussed earlier. To account for the diversity within and *between* systems, allowing for an appreciation of nested complex adaptive systems to develop, Kauffman uses a concept he calls 'patches'. In doing so, he addresses how a level of autonomy, and with that free will, can develop in conjunction with a level of co-evolution that is not reliant upon a 'central administrator'. Interestingly, by following this path, Kauffman evokes, as a scientist, and not an economist or political theorist, the invisible hand of Smith.[199] Further, Kauffman

---

194 Holland, *Emergence: From Chaos to Order*, see ch.10.

195 Holland, *Hidden Order,* pp. 35-7.

196 ibid., A strong fractal element is present here see Mandelbrot's work on the fractal dimensions of coastlines. Mandelbrot, 'Stochastic Models for the Earth's Relief, the Shape and the Fractal Dimension of the Coastlines', pp. 3825-3828.

197 Holland, *Hidden Order*, pp. 38-9.

198 Holland and Kauffman have a long history of working together at the Santa Fe Institute. See Waldrop, *Complexity*, passim.

199 Kauffman, *At Home in the Universe*, p. 262. Similarities can also be found with Holland's concept of 'tiers' whereby 'selecting appropriate characteristics, the theorist can limit the variation in the individual reaction rates within each aggregate', Holland, *Hidden Order*, p. 167.

suspects 'that analogous of patches, systems have various kinds of local autonomy, may be a fundamental mechanism underlying adaptive evolution in ecosystems and cultural systems'.[200] Through this process the 'whole is broken into parts', but parts that overlap.[201]

To link to concepts discussed earlier, natural selection and self-organisation principles can be seen to drive complex adaptive systems (in reference to phase/state space) to a position of being 'poised'; that is, a state between order and chaos.[202] A complex system, guided by selection and the self-organisation that naturally arises, may well 'build towards and sustain a characteristic poised order, an entire ensemble coursing back and forth along a high-dimensional boundary between order and disorder'.[203] It is from this that Kauffman has constructed his *belief* that complex adaptive systems seek a 'grand compromise between structure and surprise'.[204] From this, and with these concepts in mind, a definition of a complex adaptive system arises:

> The study of complex adaptive systems is the study of systems limited in their predictability. Because complex adaptive systems are systems in which microscopic interactions and evolutionary processes give rise to macroscopic phenomena through nonlinear interactions, these systems are subject to path dependence, with implications for the likelihood of multiple stable states, chaotic dynamics and frozen accidents.[205]

[200] ibid., p. 264.
[201] ibid., p. 270.
[202] Kauffman, *Origins of Order*, pp. 218-21. Kauffman stresses that 'Such poise systems appear to be best able to coordinate complex, flexible behaviour and best able to respond to changes in their environment', ibid., p. 29.
[203] ibid., p. 30. A 'poised' state 'optimizes the complexity of task the system can perform and simultaneously optimizes evolvability', ibid., p. 179.
[204] Kauffman, *At Home in the Universe*, p. 15. Indeed, his beliefs are Kuhnian in there dogma
[205] Levin, 'Complex Adaptive Systems', p.17. Indeed, 'Complex organization of living organisms can be shown to arise spontaneously given the existence of an ensemble, that is, a large collection of similar systems. Complexity has been defined as the ability to make transitions, that is, to evolve. According to Murray Gell-Mann, a "complex adaptive system" is a collection of simple parts that interact to form a complex whole capable of learning about, and reacting to, the outside world', George Modelski, 'Evolutionary Paradigm for Global Politics', *International Studies Quarterly*, vol. 40, no. 3, 1996, p. 392.

These systems are open and living, whether they be cells or cities, and will 'die when cut off from their environment'[206] (the only true equilibrium in such systems[207]). Self-organisation is the means by which complex adaptive systems 'naturally progress from chaotic, disorganized, undifferentiated, independent states to organized, highly differentiated, and highly interdependent states'.[208] Self-organising complex systems, like biological systems, are not only 'thermodynamically open systems', but 'their internal organization insures that not every region of the phase space is equally open to exploration'.[209] Basically, points of attraction are realised:

> The order in these open nonequilibrium thermodynamic systems derives from the ordered regime; in turn, the order of the ordered regime derives from the fact that nearby states tend to converge. The system therefore 'squeezes' itself onto tiny attractors. Ultimately it is this self-squeezing into infinitesimal volumes of state space that constitutes the order. And while I have called it order for free, meaning that such order is spontaneous and natural, it is not for free' thermodynamically. Rather, in these open systems, the self-squeezing is 'paid for' thermodynamically by exporting heat to the environment. No laws of thermodynamics are violated or even contested. What is new is that vast open thermodynamic systems can spontaneously lie in the ordered regime.[210]

The adaptive and self-organising nature of these far-from-equilibrium systems means that should an element fail, decompose or simply be removed, then systems can reorganise, making compensations which may or may not result in

[206] Prigogine and Stengers, *Order Out of Chaos*, p. 127.
[207] Kauffman, *At Home in the Universe*, p. 52. Whereas 'nonequilibrium is the source of order. Nonequilibrium brings order out of chaos', Prigogine and Stengers, *Order Out of Chaos*, p. 287. However, almost paradoxically, homeostasis is important to stave of small perturbations. Kauffman, *At Home in the Universe*, pp. 79-80.
[208] Eidelson, 'Complex Adaptive Systems in the Behavioral and Social Sciences', p. 47 Drawing on another scholar Eidelson defines self-organisation as 'a process by which a structure or pattern emerges in an open system without specifications from the outside environment', ibid.
[209] Robert C. Richardson, 'Complexity, Self-Organization and Selection' *Biology and Philosophy*, vol. 16, no. , 2001, p. 671.
[210] Kauffman, *At Home in the Universe*, p. 92.

changes or niches to the overall system.[211] From, and because of, this, structures emerge from the system that are not bound by a positivist framework:

> Complex adaptive systems are connective structures that exhibit re-entrant connections whereby energy is translated into structure that, in turn, can absorb more energy. This is aided by the absorption of information and the formation of knowledge structures that can be drawn upon in energy seeking. Forces that maintain order coexist with forces pushing a system towards disorder, allowing both flexibility and structural integrity.[212]

These edge-of-chaos systems support the 'interplay between the fragility and stability'. Substantial change can occur from the smallest perturbation, while, paradoxically the same systems can display an impressive resilience and will deny considerable efforts, 'whether measured in time, money, or creative energy', to effect change.[213] Complex systems are resilient yet how this is imagined is important. 'Structural deepening' occurs, rather prescriptively according to one scholar, facilitating greater complexity within a system, so that 'it can operate in a wider range of environments and enhance its resilience by improving its performance and ability to adjust to exceptional circumstances'.[214] That 'relationships can be fairly fixed and static, others fairly fluid'[215] allows for easy correlations to human society from the way in which economics is approached, to political systems and to how the course of history is understood. Taking then that 'complex adaptive systems has [sic] found expression in everything from cells to societies'[216] the question that this begs is how, then, does one construct or understand an idea of social complexity. One of the founders of the Santa Fe Institute, George Cowan, certainly envisaged the applicability of complex

---

[211] Eidelson, 'Complex Adaptive Systems in the Behavioral and Social Sciences', p. 47.

[212] John Foster, 'From Simplistic to Complex Systems in Economics' *Cambridge Journal of Economics* 2005, vol. 29, 2005, p. 876.

[213] Eidelson, 'Complex Adaptive Systems in the Behavioral and Social Sciences', p. 64

[214] Kavalski, 'Emergence of Complex International Relations Theory', p. 440. See also Rosenau.

[215] Cilliers, 'What Can We Learn From a Theory of Complexity', p. 32.

[216] Levin, 'Complex Adaptive Systems', p. 3. Yet unfortunately Levin continues stating that 'Much of our understanding of complex adaptive systems comes from observations of Nature, or from simulations, and a daunting challenge is to summarize these observations mathematically. In essence, we need a statistical mechanics of heterogeneous populations, in which new types are continuously appearing through a variety of mechanisms, mostly unpredictable in their details.' ibid.

approaches to human systems, but cautions that they do differ significantly phenomenologically from non-human complex adaptive systems.[217] The key, it would seem, lies in acknowledging emergent realities, adding weight to the argument that emergence is the definitive value that captures complex systems. The following section argues that a system is more than its constituent parts, and it is forever bound in a relationship where both the whole and the parts influence, and are influenced by, each other.

Emergence

Emergence, like many ideas, is not new. John Stuart Mill put forth an argument, an idea he called 'Emergentism', that accepted the irreducibility of the whole.[218] Aristotle's influence has already received mention, with the defining phrase that the 'whole is more than the sum of the parts'. Appreciative of this view, some complexity theorists are fond of suggesting that 'two plus two equals five', a suggestion that, on the surface, seems illogical. Yet, as a not entirely serious equation, it beautifully captures the anti-reductionism towards traditional approaches and celebrates the significance of how a whole, which creates and is created by its constituent parts, becomes a knowable entity.[219] George H. Lewes, the English philosopher and pioneering psychologist, coined the term towards the end of the nineteenth century. Lewes noted the 'qualitative novelty' of particular phenomena, meaning that, to quote Corning, certain 'material changes cannot be expressed in simple quantitative terms; they are emergents rather than resultants'.[220] With greater detail Lewes explains:

---

[217] Steve Bunk, 'The Institute Different', *The Scientist: The News Journal of the Life Sciences*, vol. 15, no. 4, 2001, p. 14.

[218] Jaegwon Kim, 'Being Realistic About Emergence', in Philip Clayton and Paul Davis, *The Re-Emergence of Emergence: The Emergent Hypothesis From Science to Religion*, Oxford University Press, Oxford, pp. 189-90. In the same volume also se Paul Davies, 'Preface', pp. x-xii.

[219] Examples of the 2+2=5 'equation' are abound but for quick reference the popular works of Murray Gell-Mann can be consulted, as can Mitchell Waldrop's *Complexity: Life at the Edge of Chaos*, passim.

[220] Peter A. Corning, 'The Re-Emergence of "Emergence": A Venerable Concept in Search of a Theory', *Complexity*, vol. 7, no. 6, 2002, p. 19. See also Goldstein, 'Emergence as a Construct', p. 53 and R. Keith Sawyer, 'The Emergence of Creativity', *Philosophical Psychology*, vol. 12, no. 4, 1999, p. 448.

> Every resultant is either a sum or a difference of the cooperant forces; their sum, when their directions are the same – their difference, when the directions are contrary. Further, every resultant is clearly traceable in its components, because they are homogenous and commensurable… It is otherwise with emergents, when, instead of adding measurable motion to measurable motion, or things of one kind to other individuals of their kind, there is a cooperation of things of an unlike kind... The emergent is unlike its components in so far as these are incommensurable, and it cannot be reduced to the sum of their differences.[221]

Consequently, to speak of emergence as an altogether new phenomenon would be to ignore a notable lineage. As Peter Corning suggests, it is probably more appropriate to speak of the 're-emergence of emergence'.[222] However, despite its long gestation, no single definition of emergence conclusively captures its ethos,[223] as to do so would possibly compromise it as an idea. This sentiment, at some level, needs to be pushed aside, as comprehension inescapably requires an element of reduction. That said, at its shortest, emergence can be understood as the appreciation of 'historical novelty',[224] whereby the 'regularities of behaviour' within a given system can be said to transcend its own ingredients.[225] The consequence, for those wishing to study complex systems, is that once a system is defined by emergent properties, it has reached a point whereby the vast numbers of interacting elements and their shared relationship have achieved a level of such complexity that disallows any practical ability, or, in many instances, even the possibility of monitoring each and every interaction.[226] This is the paradigmatic shift that occurs when moving from reductionism to emergence and, importantly, it underscores that as:

---

221 ibid., quoted from G. H. Lewis, *Problems of Life and Mind*, Truebner, London, 1874-9.
222 Corning, 'The Re-Emergence of "Emergence"', p. 18. On emergence see also Newman, 'Emergence and Strange Attractors, pp. 245-61.
223 Although Corning pushes that Goldstein's work can be considered as a good approximation. Corning, 'The Re-Emergence of "Emergence"', p. 22.
224 Drawing on Cederman, Kavalski, 'The Fifth Debate and the Emergence of Complex International Relations Theory', p. 439.
225 Cohen and Stewart, *Collapse of Chaos*, p. 232.
226 Lansing, 'Complex Adaptive Systems', p. 185.

we shift our attention from the causal forces at work on individual elements to the behaviour of the system as a whole, global patterns of behaviour may become apparent. However, the understanding of global patterns is purchased at a cost: The observer must usually give up hope of understanding the workings of causation at the level of individual elements.[227]

Reductionism is undone and in its place enters uncertainty. As Stephen Jay Gould argued, the moment 'you have emergent characteristics due to nonadditive interaction among lower-level entities, then you can't reduce to the lower-level entities, because the nonadditive features have emerged'.[228] However, the desire to display a level of triumphalism and to speak of the demise of reductionism and the ascendency of holistic approaches should be tempered, if only a little. The presuppositions that support the notion of a complex adaptive system place importance on both individual elements and the system as a whole, a point that should not be overlooked. Emergent systems arise via the complex local interaction of a diverse and plentiful array of agents. Consequently, the actions of individual agents have the ability to 'drive evolutionary change from the bottom up', allowing the system to emerge 'from the interplay of processes at diverse scales'.[229] Moreover:

> A system far from equilibrium may be described as organised not because it realizes a plan alien to elementary activities, or transcending them, but, on the contrary, because the amplification of a macroscopic fluctuation occurring at the 'right moment' resulted in favouring one reaction path over a number of other equally possible paths. Under certain circumstances, therefore, the role played by individual behaviour can be decisive.[230]

---

[227] ibid.

[228] Stephen Jay Gould, 'The Patterns of Life's History' in John Brockman, ed., *The Third Culture: Beyond the Scientific Revolution*, Simon & Schuster, 1995, http://www.edge.org/documents/ThirdCulture/i-Ch.2.html accessed 19/4/04.

[229] Levin, 'Self-Organization and the Emergence of Complexity', p. 1077.

[230] Prigogine and Stengers, *Order Out of Chaos*, p. 176. Drawing on Anthony Giddens, the critical realist Roy Bhaskar reinforces the idea that 'society is thus both the condition and out come of human agency … and human agency both the production and reproduction … of society', Harvey, 'Agency and Community', p. 173. This duality can be easily construed to bearing a relationship to the bifurcation that occurs in non-linear dynamical systems. Indeed, in very structural terms Harvey later posits that 'When institutions become unstable and approach a crucial bifurcation point, an otherwise insignificant shift in conduct by a strategically placed person or group of persons can produce a cascade of profound institutional changes. In this way,

So a contrapuntal dialectic plays out with self-organising principles pushing, and pulling, complex systems in and about basins of attraction in a theoretical phase space. Those attractors are bound by what has been discussed as an 'edge of chaos' phenomenon, and yet it is the individual agents, via their 'decisions' and interactions, that will push a system in a patterned but unpredictable fashion.

Further, evolution in these far-from-equilibrium systems is irreversible in the sense that original configurations are never realised, undermining traditional ideas of equilibrium built upon notions of negative feedback. The system finds a new 'equilibrium point' on which to stabilise – thus for those incorporating non-linear approaches 'stasis and equilibrium' are 'transitional points of repose'.[231] Effectively, momentary and non-permanent points of stability that will inform the system into the future. These ideas are gaining recognition within the social sciences. Specifically, in respect to revitalising theories of IR with lessons learned from complexity, Emilian Kavalski contends that a theory of complex international relations should invoke the '*dialogic principle*'.[232] This would allow for an 'aporetic duality (between agency and structure, for example) while at the same time transcending that duality and creating a unity of the whole'.[233] In this, a 'complex phenomenon' can be conceived through the interaction of contradictory elements.[234] Effectively, Kavalski attempts to maintain the supposed paradoxical position of honouring the integrity of both the aggregate, that is the whole, and the components or agents that exist within it; both are tied in a dance of creation and evolution with each other.[235] Einstein was only partially right when he

Bhaskar's dependencies suddenly become a very real basis for inducing or exacerbating social crises', ibid. p. 187.

231 Harvey and Reed, 'The Evolution of Dissipative Social Systems', pp. 384-5.

232 Kavalski, 'Emergence of Complex International Relations Theory', p. 444.

233 ibid. He also, quite rightly presses the '*principle of recursivity*, in which causes simultaneously are effects' and the '*the holongrammic principle*, based on the notion of 'holons'—whole/parts—entities that are both wholes and parts of ever greater wholes, simultaneously and at all times'

234 Marie-Joëlle Browaeys and Walter Baets, 'Cultural Complexity: a New Epistemological Perspective', *The Learning Organization*, vol 10, no. 6, 2003, p. 337.

235 Kavalski, 'Emergence of Complex International Relations Theory', p. 439.

claimed that 'God does play dice with the universe'. Indeed, as physicist Joseph Ford declared, the dice are loaded.[236]

Before progressing further, the work of Stephen Wolfram is in need of specific mention.[237] Wolfram, who favours the term 'computational irreducibility'[238] over that of emergence, in his self-declared and self-published *opus* strongly pushed his belief in the singularity of his ideas and that they are a challenge to the study of complexity. Yet his ideas of simple underlying rules, which are important, are hardly the revelation to students of complexity, irrespective of the extent to which he wished to elevate his own status in the field. Moreover, his suggestion that the study of complexity stalled in the mid-1990s due to his belief that issues in 'social and biological sciences' were too 'hard to pin down'[239] misses the point, and does so badly. Wolfram, despite his brilliance, cannot escape the man-as-scientist parameters in his search for more concrete answers. This is unfortunate, as certain elements of his work are very important. Building on his idea of computational irreducibility, Wolfram speculates that human will is to be considered free, as irrespective of what 'rules' or 'laws' that govern our brains, irreducibility means that the overall behaviour cannot be bound by some level of 'iron law'.[240] Furthermore, drawing on Hayek (and bearing a resemblance to the work of Heisenberg), he asserts, with a level of conjecture, that the unpredictable behaviour of people is because our 'brains can only explain systems simpler than themselves and can thus never explain their own behaviour'.[241] Complexity, it would seem, is always going to befuddle. Consequently, the role of the theorist is

[236] Gleick, *Chaos*, p. 314. Indeed, Weber, long before had written on the concept of '"loaded" dice'. See Max Weber, *The Methodology of the Social Sciences*, trans and eds, Edward A. Shils and Henry A. Finch, The Free Press, Glencoe, 1949, p. 183.

[237] Wolfram is a curious figure whose arrogance and the 'destruction wrought by it has left a trail of bad feeling smouldering behind him' at a range of prestigious institutions and it is, in part fuelled by his 'amazing lack of respect for the work of other people', Robert Hotz, 'A Study in Complexity', *MIT's Technology Review*, vol. 100, no. 7, pp 23-9.

[238] Seemingly wanting to maintain a language of science (and perhaps maintaining its exclusivity). The defining notion of his concept of irreducibility is that irrespective of what 'definite underlying laws' may govern any given system the 'overall behaviour can still have aspects that fundamentally cannot be described by reasonable laws' Wolfram, *New Kind of* Science, p. 750. Wolfram was discussed earlier for his influential work with cellular automata.

[239] ibid., pp. 862-3.

[240] ibid., p. 750. Linking in with Kauffman's work discussed earlier.

[241] Wolfram, *New Kind of Science*, p. 1135.

to recognise patterns and points of attraction that are diverse, that evolve and that are unpredictable. This can take many different forms, but a 'complexity paradigm' allows for a diversity of theoretical constructions that move away from the paradigmatically dominant worldview.

For example, David Harvey presents an 'ontologically stratified' vision that privileges structure (and would most likely catch the ire of those positioned on the relativist slope). From a critical realist perspective he posits a reasonably persuasive position, whose ideas on stratification are easily aligned to the work of Holland, in that:

> the resulting strata are *emergent realities* in that each level is the product of the reproductive mechanism in the more basic strata grounding it: but, for all that, these emergent strata are not strictly reducible to those more basic strata and structures. Finally, those strata are hierarchically structured and loosely nested to form an ontologically layered, historically open system.[242]

Diversity, interaction, communication and emergent structures can be said to define the whole. This mimics Kauffman's views on the very essence of life which 'emerged whole and has always remained whole. Life, in this view, is not to be located in its parts, but in the collective emergent properties of the whole they create'.[243]

[242] Harvey, 'Agency and Community', p. 165. Further, 'By dint of being reciprocally interactive entities, causal movements often take the form of non-linear feedbacks that operate in staggered rhythms to produce a world of historically constituted, evolving constellations. This open, interactive world of things and contingent tendencies constitutes the proper object of scientific investigation', ibid. His argument reaches its zenith in the ideas that 'social structure, by dint of supplying the material and cultural wherewithal through which agency is formed, not only lays the foundations for its own orderly reproduction, but delimits the range of alternative strategies and actions by which human agency can reproduce and transform social structure itself. Conversely, agency, in that it ultimately reproduces social structure and the material foundations of the social, also reproduces the field of possible social configurations which constrain and enable its own future projects of self-transformation.' ibid., p. 174

[243] Kauffman, *At Home in the Universe*, p. 25.

Conclusion

This chapter has done more than 'lay groundwork', it has established the importance of a non-linear paradigm that departs from positivist accounts of how the world *is*, and, instead, pushes the argument of the continual *emergence* of order. In doing so, it has been argued that a revolution, to take Kuhn's use of the term, is necessary to alter the dominant paradigmatic presuppositions that define scientific enquiry and, from that, the scientific imagination and all that follows. This chapter has established new foundations from which to interpret the social, political, economic and international worlds; self-organisation, uncertainty and the emergence of non-additive wholes have been shown to be endogenous to complex systems. Linearity and predictability, a nineteenth century ontological hangover, have been challenged, and the emergence of the whole takes precedence. The consequence, when examining social, political and economic systems, is that a space is opened for intuition and interpretation to play an important role without them being deemed as 'unscientific'. This is coupled with a reconceptualisation of order, when supported by the presuppositions laid out at the beginning of the chapter, that encourages the possibility of an IR theory of emergence.

The study of political systems, including the international system, inevitably looks toward, or for, ordering principles. As Bull suggested, the attachment felt for order occurs, in part, because of 'the greater predictability of human behaviour that comes as the consequence of conformity…'.[244] However, two important points need to be highlighted in the face of such assertion. The first is that order of some kind will inevitably arise, the second is to stress the difficulty in disentangling 'the meaning of the words such as "order" and "chaos"'; for example is 'a typical forest an ordered or a chaotic system?'[245] These concepts will be looked at in further detail, however at this stage the argument is proposed that the Newtonian paradigm informs notions of order by framing how it is imagined and, through that lens, how it is both supported and contested in various

[244] Bull, *The Anarchical Society*, p. 7.
[245] Prigogine and Stengers, *Order Out of Chaos*, p. 169.

discourses. For Kauffman, the consequence of accepting the Newtonian vision of the world has resulted in the West's 'lapse from paradise', with:

> … Copernicus to Newton in celestial mechanics, to Darwin in biology, and to Carnot and the second law of thermodynamics – [leaving] us spinning around an average star at the edge of a humdrum galaxy, lucky beyond reckoning to have emerged as living forms.[246]

What paradise represents in this regard is contestable, but at one level its abandonment can be seen as the sidelining of hermeneutical interpretation in the face of axiomatic reductionism. Newton, chief among them, wrenched humankind farthest from this paradise, while complexity, in Kauffman's view, offers an opportunity to regain paradise;[247] a view of the world that celebrates the richness of interactions and the continual re-emergence of the whole. This belief sustains the argument that the scientific imagination needs to undergo a revolution, one which the social sciences are able to attach themselves to, and one which the artist would have claimed to have known all along. This is the paradigm switch, the 'tragic, metaphysical choice',[248] that needs to eventuate. Imagining order as an emergent reality is the appropriate focus for a *social science* research agenda that seeks to explain how an international system functions. The complex *social* web that is the international environment may be bound by material factors, and contain agreed aggregate communities like states. However, it is not a fixed, mechanical clockwork structure. Instead it is an array of social systems and, when 'unconcealing' a worldview, what is being explored when one speaks of systems is a 'methodological collectivism masquerading as a description of social reality'.[249] By integrating this realisation it becomes evident that concepts that are open to variation, unpredictably and amorphousness are considerably better suited to the study of international social orders. Stanley Hoffmann, writing on the subject of war over four decades ago, stated that the social scientist must

[246] ibid., p. 71. Pushing away from both secular rationalism and creationist doctrine Kauffman insists that it was 'science, not sin' for which paradise was forsaken. Kauffman, *At Home in the Universe*, p. 10.
[247] Kauffman, *At Home in the Universe*, pp. 4-6.
[248] Prigogine and Stengers, *Order Out of Chaos*, p. 32.
[249] Onuf, *World of Our Making*, p. 131.

admit to 'the limits of our knowledge'.[250] These are the ideas that are pursued in the final chapters.

[250] Stanley Hoffmann, *The State of War: Essays on the Theory and Practice of International Politics*, Pall Mall Press, London, 1965, p. 273.

4

Disturbing the Natural Balance

All political thinking for years past has been vitiated in the same way. People can foresee the future only when it coincides with their own wishes, and the most grossly obvious facts can be ignored when they are unwelcome.[1]

This chapter argues that the Newtonian paradigm has long framed how leading theories of IR are conceptualised, with the consequent significance of capturing how international relations (what is 'out there') is understood. Most notably, the idea of a natural equilibrium, a natural point of return, in an anarchic system has become a central concept within the discipline.[2] Bearing the authority of science, and trading on the privilege associated with laws,[3] has allowed a linear and, in a

---

[1] George Orwell, 'London Letter to *Partisan Review*: December 1944', *Partisan* Review, 1945 in *The Collected Essays, Journalism and Letters of George Orwell: As I Please: 1943-1945*, vol. 3, Sonia Orwell and Ian Angus, eds, Secker and Walburg, London, 1968, p. 297.

[2] This is true even of many theories that are positioned in opposition to the dominant rationalist schools. As Vasquez, a little caustically, points out, 'the very foundation upon which post-modernism makes its appeal is in fact parasitic on an alternative epistemology and view of the world', John Vasquez, *The Power of Power Politics: From Classical Realism to Neotraditionalism*, Cambridge University Press, Cambridge, 1998, p. 225.

[3] This is not contained to realism alone, take democratic peace thesis, that is the 'idea that democracies never fight wars against each other has become an axiom for many scholars. It is, as one scholar puts it, "as close to anything we have to an empirical law in international relations." This "law" is invoked by American statesmen to justify a foreign policy that encourages democratization abroad.' Edward D. Mansfield and Jack Snyder, 'Democratization and War', *Foreign Affairs*, vol. 74, no. 3, 1995, p. 79. This being an example of how the certainty from a scientific paradigm travels first into theory making in the natural science before being transferred into the public realm.

broad sense, predictable conceptualisation of world politics to take hold. A sometimes explicit, and, at other times, more subtle process, this scientific approach to international relations has, for example, been referred to as scientism, scientificism, and as scientistic.[4] However, the end of the Cold War, coinciding with greater interdisciplinary exchange, challenged some of the preconceptions of IR theorists. John Lewis Gaddis was quick to assert that 'a methodological passing of ships in the night' had occurred, where social scientists, in the positivist tradition, continued to incorporate the Newtonian science of prediction, whilst many hard and natural scientists were well along the path of non-linear science.[5] In essence, the end of the Cold War exposed linear and reductionist theories as being unable to sufficiently explain the dynamic and seemingly unpredictable changes that continue to impact simultaneously upon international and domestic structures.[6] The end of bipolar stability, and, similarly, the terrorist attacks of September 11, acts as a potent reminder that 'surprise is still very much with us'.[7]

Rosenau asks how major turns and 'historical discontinuities' challenge the 'fundamental structures of world politics'.[8] This chapter answers the question by examining how science has framed the discipline. The argument proceeds in six stages. First, the idea of order and anarchy as the foundational starting point for theories of international relations[9] is explored. It is argued that the idea of anarchy is representative of a dichotomy built on fear that pervades human cultures, and ordering it becomes a conceptual imperative. Second, power becomes the currency of order. However, it is argued that the manner in which power is conceived will

---

[4] Seán Molloy, 'Realism: A Problematic Paradigm', *Security Dialogue*, vol. 34, no. 1, 2003, p. 71; Seán Molloy, 'Truth, Power, Theory: Hans Morgenthau's Formulation of Realism', *Diplomacy and Statecraft*, vol. 15, no. 1, 2004, p. 5, and; Hedley Bull, 'International Theory: The Case for a Classical Approach', *World Politics*, vol. 18, no. 3, 1966, pp. 361-2. Bull mentions that he will refer to the science as opposed to a scientistic approach, 'so as not to prejudge', arguably indicating his prejudice from the outset. ibid. See also, on science and politics in the post-war period, John G. Gunnell, 'Paradoxos Theoretikos' in Kristen R. Monroe, ed., *Contemporary Empirical Political Theory*, University of California Press, Berkley, 1997, pp. 47-70. Stanley Hoffman noted that there were 'many contemporary heirs of a Comtean *scientisme* that tries to reduce the sum total of human activity to a set of laws.' Hoffmann, *The State of War*, p. 275.

[5] Gaddis, 'International Relations Theory', pp. 53-54.

[6] Rosenau, 'Many Damn Things Simultaneously', pp. 73-6.

[7] Gaddis, 'International Relations Theory', p. 5.

[8] Rosenau, *Turbulence in World Politics*, p. 4.

[9] Particularly neorealism and neoliberalism which are built upon a 'shared commitment to rationalism', Wendt, 'Anarchy is What States Make of it', p. 391.

influence how theories of international order are constructed. The third section emphasises that the desire to create a science of international relations is contained within the Newtonian paradigm, with order, anarchy and power neatly fitting into the reductionist model for which they were intended. This is an argument that is primarily pursued via an exploration of the 'science' of realism and, to a lesser extent, neoliberal institutionalism. Yet, the ontological essence of the scientific approach often occurs via transference from economics.[10] This fourth stage identifies how the economic worldview has significantly contributed to cementing how mainstream international relations is studied and understood.

The final two sections deal with the idea of balance. Balance, indeed *natural* balance, embraces the notion that a self-regulating equilibrium is achieved via negative feedback processes.[11] Within the social sciences, much of transference can be traced to the Smithian-inspired and influential metaphor of an invisible hand.[12] This conceptualisation of a single point of equilibrium to which all change is directed is a hallmark of Newtonian systems. Furthermore, it is this imagined idea of the closed system that is contested. In addition, the representation of a system as being 'fully defined or ideal', creating an impression of 'reality in its simplest form', is similarly objected to.[13] It is argued that balance of power theory, as the most widely accepted variant of this approach, is effectively a construct that assists in explaining after the fact, in doing so maintaining an image of order. It is in the final stage that the argument for an appreciation of far-from-equilibrium process is made. Here, systems would be considered as being non-ideal or only 'partially defined,' and being of 'a higher degree of complexity than [the] ideal

[10] The emphasis is on neoclassical economics, but the root lies in classical economics and, much later, the positivists school. In general is can be said that the 'Rationalists' within IR have drawn their assumptions from economics. Indeed to speak of rationalist within IR is to speak of those who utilise 'neo-positivist methodologies' and are 'economistic in tone'. Rengger, *International Relations, Political Theory, and the Problem of Order*, pp. 15-16.

[11] On the international system being driven via negative feedback processes see Karl W. Deutsch and David J. Singer, 'Multipolar Power Systems and International Stability', *World Politics*, vol. 16, no. 3, 1964, p. 393.

[12] The use of the term 'Smithian' is important here. In the same way that Newton may not agree with all things determined to be Newtonian, the same can be said of Smith. Indeed, Smith saw little correlation between his analogy of an invisible hand and what might be called balance of power theory. See Andrew Wyatt-Walter, 'Adam Smith and the Liberal Tradition in International Relations', *Review of International Studies*, vol. 22, no. 1, 1996, pp. 5-28, esp. pp. 21-2.

[13] Herrmann, *From Biology to Sociopolitics*, p. 2.

systems' of the Newtonian world.[14] The argument is not that balance does not occur, but rather that balance is a high-energy process[15] that does not negatively feed-back to a single stable point of equilibrium. Instead, the international system should be understood as operating at multiple levels, driving and moving around multiple points of equilibria. Systems are poised, and are attracted to stable patterns of behaviour that never exactly repeat and can make sudden and unpredictable changes. The end of the Cold War was a dynamical process that simply could not be captured by traditional models.[16] The non-linear sciences offer the opportunity to re-frame how international politics is understood so that scholars are able 'to embrace the newly-*apparent* dynamism and uncertainty.'[17]

Controlling Chaos: Order and Anarchy

Chapter Two established the importance of chaos and order to human societies. It is from chaos that many of the creation myths emerged, in time, particularly within the Western imagination. Chaos, disorder and unpredictability became something to be feared – a regression to an uncivilised past. It is Hobbes who captured this fear in his most enduring passage:

> Whatsoever therefore is consequent to a time of warre, where every man is Enemy to every man, the same consequent to the time, wherein men live without other security, than what their own strength, and their own invention shall furnish them withall. In such condition there is no place for Industry; because

[14] ibid., p. 3.
[15] Drawing from weather analogies, Rosenau recognises that 'Turbulence needs a continuous supply of energy… If no energy is applied turbulence decays rapidly.' Rosenau, *Turbulence in World Politics*, p. 56. Remembering that 'Turbulence is not a feature of fluids but of fluid flows.' ibid.
[16] Indeed, for Vasquez, realism's failure to both capture and explain the end of the Cold War is more indicative of its 'underappreciation of change and its inability to explain it'. Vasquez, *The Power of Power Politics*, p. 317. Moreover, 'there is no doubt that none of the well-known realist variants expected the Cold War to end the way it did.' ibid., p. 323. And further 'The shift in Soviet foreign policy [was] simply too radical for the logic of realist theory'. ibid., p. 330. John Mearsheimer bravely continued the paradigm defence claiming, again in the wake of the end of the Cold War, that peace in the international system was not influenced by domestic politics. John Mearsheimer, 'Why We Will Soon Miss the Cold War', *Atlantic Monthly*, vol. 266, no. 2, August 1990, p. 37. A further irony is highlighted by the failure of (neo) realist theory to comprehend 'how obvious the asymmetry in power between the two sides of the Cold War actually was.' Caroline Kennedy-Pipe, 'International History and International Relations Theory: A Dialogue Beyond the Cold War', *International Affairs*, vol. 76, no. 4, 2000, p. 747.
[17] Hoffmann and Johnson, 'Change and Process in a Complex World' URL. Emphasis added.

> the fruit thereof is uncertain: and consequently no Culture of the Earth; no Navigation, nor use of the commodities that may be imported by Sea; no commodious Building; no Instruments of moving and removing such things as require much force; no Knowledge of the face of the Earth; no account of Time; no Arts; no Letters; no Society; and which is worst of all, continuall fear, and danger of violent death; and the life of man, solitary, poore, nasty, brutish, and short.[18]

The disorder of chaos was the recognition that if no sovereign contained or restrained the excesses of 'man', life would rapidly descend into a situation 'where every man is Enemy to every man'.[19] It is an argument of human nature and original sin. Without government there is only anarchy. As Waltz points out: 'Among men as among states, anarchy, or the absence of government, is associated with the occurrence of violence'.[20] However, Hobbes alone should not bear the burden. Jean-Jacques Rousseau spoke of anarchy, in more tempered tones,[21] but Vico saw little difference to the world Hobbes imagined should the pendulum swing from a world of order to that of chaos. Vico, providing also a warning to the excesses of man and that the anarchy or chaos of the past forever lingered, wrote:

> But as the popular states became corrupt, so also did the philosophies. They descended to skepticism. Learned fools fell to calumniating the truth. Thence arose a false eloquence, ready to uphold either of the opposed sides of a case indifferently. Thus it came about that, by abuse of eloquence like that of the tribunes of the plebs at Rome, when the citizens were no longer content

[18] Hobbes, *Leviathan*, pt. I, ch. xiii, p. 186. His other most oft quoted passage, which can be interpreted as the earliest recognition of a security dilemma reads: 'But though there had never been any time, wherein particular men were in a condition of warre one against another; yet in all times, Kings, and persons of Soveraigne authority, because of their Independency, are in continuall jealousies, and in the state and posture of Gladiators; having their weapons pointing, and their eyes fixed on one another; that is, their Forts, Garrisons, and Guns upon the Frontiers of their Kingdomes; and continuall Spyes upon their neighbours; which is a posture of War'. ibid, pt. I, ch. xiii, pp. 187-8

[19] ibid., pt. I, ch. xiii, p. 186.

[20] Waltz, *Theory of International Politics*, p. 102

[21] Rousseau declares that 'men are not natural enemies', Jean-Jacques Rousseau, *Of the Social Contract or Principles of the Political Right* in the *Social Contract and Other Later Political Writings*, Victor Gourovitch, ed., Cambridge University Press, Cambridge, 1997 [1762], [I.iv.7], p. 46. Rousseau also refers the 'horrible system of war', with the state of war not being natural [OC III, 607] and, later, he speaks of the 'Error of Hobbes…' [OC III, 612], Jean-Jacques Rousseau, *State of War* in ibid., pp. 163-4. See also Kenneth N. Waltz, *Man, the State and War: A Theoretical Analysis*, Columbia University Press, New York, 1959, pp. 6-7, 12, 172-5.

with making wealth the basis of rank, they strove to make it an instrument of power. And as furious sound winds whip up the sea, so these citizens provoked civil wars in their commonwealths and drove them to total disorder. Thus they caused the commonwealths to fall from a perfect liberty into the perfect tyranny of anarchy or the unchecked liberty of the free peoples, which is the worst of all tyrannies.[22]

Yet it is Hobbes for whom the discipline of international relations looks to when tracing the genealogy of anarchy, so that an anchor may be dropped, attaching itself to an essentialism with political philosophy. Hedley Bull was under no illusion as to Hobbes's role in the construction of this idea.[23] In short, for the school of realism there is no escaping that anarchy means '... not simply the absence of hierarchical government, but the presence of a Hobbesian state of nature'.[24] It *is*, in other words, 'the presence of disorder and chaos'.[25]

Specifically, order and anarchy are defined in international relations by the division separating the international from the domestic. Indeed, it is the domestic analogy that frames and contains how the international system is imagined.[26] Waltz is quick to point out that if anarchy results in 'chaos, destruction, and death'

[22] Vico, *The New Science*, p. 423. Vico has more to say on the absence of a sovereign: 'But if the peoples are rotting in that ultimate civil disease and cannot agree on a monarch from within, and are not conquered and preserved by better nations from without, then providence for their extreme ill has its extreme remedy at hand. For such peoples, like so many beasts, have fallen into the custom of each man thinking only of his own private interests and have reached the extreme of delicacy, or better of pride, in which like wild animals they bristle and lash out at the slightest displeasure. Thus no matter how great the throng and press of their bodies, they live like wild beasts in a deep solitude of spirit and will, scarcely any two being able to agree since each follows his own pleasure or caprice. By reason of all this, providence decrees that, through obstinate factions and desperate civil wars, they shall turn their cities into forests and the forests into dens and lairs of men. In this way, through long centuries of barbarism, rust will consume the misbegotten subtleties of malicious wits that have turned them into beasts made more inhuman by the barbarism of reflection than the first men had been made by the barbarism of sense.' ibid pp. 423-4. For an account of how this is a formative element of Vico's argument as to the nature of the development of society and civilization see: Brendan M. Dooley, *The Social History of Skepticism: Experience and Doubt in Early Modern Culture*, John Hopkins University Press, Baltimore, 1999. pp. 150-3. Moreover, the possibility of establishing an argument reconciling Vico's argument to that of Wendt's three logics of anarchy would certainly be plausible (On Wendt's logics of anarchy see Wendt, *Social Theory of International Politics*, ch. 6).

[23] Bull, *The Anarchical Society*, p. 45.

[24] John Vasquez, 'World Politics Theory' in Mary Hawkesworth and Maurice Kogan, eds, *Encyclopaedia of Government and Politics*, vol. 2, Routledge, London and New York, 1992, p. 854.

[25] Waltz, *Theory of International Politics*, p. 114.

[26] Bull, *The Anarchical Society*, p. 45.

when cast opposite the order of government, then as a concept it informs little,[27] yet in this realm of disorder Waltz is able to discern that the elements that make up the 'international-political systems stand in relations of coordination'. In a formal sense, each state is equal to all others, but no single state 'is entitled to command; none is required to obey. International systems are decentralized and anarchic'.[28] Considering this is a core component of his theory, it is pertinent to question how relations between states are framed.

It is inescapable for the realist and, in particular, the neorealist, that anarchy is viewed as a constant.[29] To counter the fear and insecurity in this anarchic international system, 'self-help' is laid out as 'the principle of action'.[30] Yet, as much as some scholars may wish to reduce the international system to inevitable use of force (the Hobbesian state of war), it cannot be ignored that international society has routinely sought to mitigate violence or promote peace throughout the ages, with 'efforts to establish procedures, techniques, institutions … in the absence of a supreme decision-making body'.[31] As Wendt and Raymond Duvall are keen to point out, neorealists 'fail to problematize the cooperation problem'.[32] For an international society does exist, and although posturing does occur, so too does trade and commerce in spite of the absence of a central power.[33] Wendt, in acknowledging the 'repeated efforts to create collective security systems after major wars in 1815, 1918 and 1945',[34] highlights the explicit desire for an international society in the face of more and more destructive wars. Further, the aggregation into states and the emergence of a system that recognises the rights of states and norms of appropriate behaviour illustrates that non-self-serving

[27] Waltz, *Theory of International Politics*, p. 103.
[28] ibid., p. 88. Moreover, Waltz contends that 'In an anarchic realm, the units are functionally similar and tend to remain so.' ibid., p. 104. These ideas are bound by what he referred to in an earlier work as his 'third image' of international politics. See Waltz, *Man, the State and War*, esp. ch. 6.
[29] Wendt, *Social Theory of International Politics*, p. 98.
[30] Waltz, *Theory of International Politics*, p. 111. The move from realism to neorealism is in part highlights a move away from the need to dominate to that of a position motivated by uncertainty and fear. Shimko, 'Realism, Neorealism, and American Liberalism', pp. 294-5
[31] Ian Clark, *Reform and Resistance in the International Order*, Cambridge University Press, Cambridge, 1980, p. 19.
[32] Wendt and Duvall, 'Institutions and International Order', p. 56.
[33] Bull, *The Anarchical Society*, pp. 45-6.
[34] Wendt, 'Why a World State is Inevitable', p. 508.

behaviour is possible.[35] Essentially, as detailed in the previous chapter, an order will always arise and, more importantly, it cannot be a preconceived idea of order. For example, Stephen Krasner, in his defence of the state, inadvertently stumbles upon a notion of how the state as a construct assists not only in creating notions of order, but exhibits its malleability beyond a mere unit of analysis floating in a sea of anarchy:

> The Westphalian sovereign state model, based on the principles of autonomy, territory, mutual recognition and control, offers a simple, arresting, and elegant image. It orders the minds of policymakers. It is an analytic assumption for neo-realism and neo-liberal institutionalism. It is an empirical regularity for various sociological and constructivist theories of international politics. It is a benchmark for observers who claim an erosion of sovereignty in the contemporary world.[36]

The nature of order is in itself imagined. That is not to say it actually does not exist, nor that it cannot be empirically shown. The point is that its conceptualisation will differ depending on the ontological assumptions that are made. For instance, it cannot be ignored that people make up states (yet it often is) – and people cannot simply be reduced to the drive for security. As Bull points out, many other factors contribute to the actions of states, including 'reciprocal interest, a sense of community or general will, and habit or inertia'.[37] Ian Clark asked the question as to whether 'various order-producing systems, in fact, create different types of international order?'[38] This line of questioning shares similarities with the constructivist school of thought in international relations. The rationalist twins of neorealism and neoliberalism strip away social elements like history and culture. Despite constantly nodding to its Hobbesian beginnings, there exists a

[35] Bull, *The Anarchical Society*, pp. 45-6. For example, As Bull acknowledges, 'Diplomatists, even in the pristine form of messengers, are visible expressions of the existence of rules to which states and other entities in the international system pay some allegiance. In the developed form of the diplomatic corps that exists in every capital city they are tangible evidence of international society as a factor at work in international society', ibid., p. 166. Indeed, Robert Jervis, a realist critical of neorealism gives a nod of approval to Bull considering the idea of 'an anarchical society, with many shared values, principles, norms, and practices' serves as an alternate explanation of some value. Jervis, *System Effects*, p. 108.
[36] Krasner, 'Rethinking the Sovereign State Model', p. 17. See also J. P. Nettl, 'The State as a Conceptual Variable, *World Politics*, vol. 20, no. 4, 1968, pp 559-592.
[37] Bull, *The Anarchical Society*, p. 46.
[38] Clark, *Reform and Resistance in the International Order*, p. 12.

strong desire to present anarchy as an *amoral* and *a-historical* constant; that is, a scientific constant. Yet, for the constructivist, history and culture remain important. For Wendt, it informs interests which then play 'an independent role in constituting the meaning of anarchy'.[39] This results in there being no single 'logic of anarchy'.[40] From this, Wendt argues that anarchy on its own 'is a nothing, and nothings cannot be structures'.[41] As there is bounded rationality, it may now be possible to speak of 'bounded anarchy'.[42] In addition, the countervailing theme that 'order itself is not normatively neutral' and it too 'carries with it certain connotations'[43] should receive similar attention. For Nicholas Onuf, order is nothing less than a fiction, and a fiction that masquerades as a reality.[44] Moreover, this reality is manufactured by 'constituting the conditions of rule', and rules preferentially 'distribute privilege'.[45] The delineating of order and chaos is a social division that is bound by the intersubjectivity that defines social phenomena. Indeed, there exists an irony here in that:

> Seeing history as fundamentally unchanging, realists were unable to explain where the structure of world politics came from in the first place and were unable to apprehend that the immutable 'laws' of the system that they were seeking to uncover might merely be social constructions of a particular epoch.[46]

In light of what has been written above, and drawing from his many critics,[47] it is not difficult to argue that 'Waltz's dichotomy between hierarchical and anarchical

[39] Wendt, *Social Theory of International Politics*, p. 109.
[40] ibid., p. 308. This ties into to Wendt idea of different anarchies (depending 'on what states *want*', ibid., p.106). Wendt devises 'three cultures of anarchy'; Hobbesian, Lockean, and Kantian. ibid., ch. 6. Take then Waltz's, contentious claim that 'the enduring anarchic character of international politics accounts for the striking sameness in the quality of international life through the millennia, a statement that would meet with wide assent.' Waltz, *Theory of International Politics*, p. 66. In light of what is being argued it is difficult to reconcile Waltz's position.
[41] Wendt, *Social Theory of International Politics*, p. 309.
[42] Vasquez, 'World Politics Theory', p. 854. See also Stanley Hoffmann, 'The Rules of The Game', *Ethics & International Affairs*, vol. 1, no. 1, 1987, pp. 37-51.
[43] Clark, *Reform and Resistance in the International Order*, p. 11.
[44] Onuf, *World of Our Making*, p. 155.
[45] ibid., p. 128. Indeed, Onuf even proposes substituting the term 'order' for 'privilege'. ibid., p. 159.
[46] Vasquez, 'World Politics Theory', p. 851.
[47] His critics are many. For a good introduction see chapters 6 to 10 in Robert O. Keohane, ed., *Neorealism and its Critics*, Columbia University Press, New York, 1986. Further, proponents of a theory rarely accept either a refutation or a substantial attack on its key ideas (akin to a paradigm defence). Instead supporters will generally attempt to redeem or salvage the general thrust before attempting to reinvent the theory; Michael

systems is excessively simplified'.[48] His divide is too strong and too stratified, a consequence of his simplified and, despite his claims to the contrary, reductionist theory-building. This is compounded by his inability to acknowledge how much order is actually present in the system. The failure stems from casting his 'anarchy-order distinction as a dichotomy, when it is better seen as a continuum'.[49] Tongue-in-cheek, Clark asks if order is to be achieved, must the international system then be required to reach a point of 'complete ossification'? He of course dismisses the idea as neither realistic nor desirable.[50] Yet this question touches upon the issue of how non-linear systems operate. Waltz's theory, like the class I and II cellular automata discussed in the previous chapter,[51] ossifies. This is because it is constrained by an absolute idea of anarchy. Order sits in opposition to disorder, meaning change is not accommodated by the theory. Waltz's structuralism becomes too ordered and it cannot account for an international system that should be properly considered as a far-from-equilibrium process. As shown in the previous chapter, systems of this nature simply do not reside at such static and unchanging points.

Taking the argument further, it should be understood that when the international system undergoes rapid change, heralded by disorder and turbulence, constants

Nicholson, *Causes and Consequences in International Relations*, Pinter, London, 1996, p. 94. In essence this will involve a greater theoretical complexity as is obvious with the debates around neo-realism and neo-liberal institutionalism which in turn has lead to declaration of a neo-neo synthesis; Anton du Plessis, 'International Relations Theory and the Discourse on Terrorism: Preliminary Reflections on Context and Limits', *Strategic Review for Southern Africa*, vol. 23, no. 2, 2001, p. 140. Whilst others have suggest that it is in fact a debate between offensive and defensive realism; See Robert Jervis, 'Realism, Neoliberalism, and Cooperation', *International Security*, vol. 24, no. 1, Summer 1999, pp. 42-63. The problem that has been identified is there are now many realisms and it is realism's 'theoretical core' that is being undermined. The defenders of realism, in their rush to preserve the great tradition have created a cacophony of competing ideas under the one theoretical umbrella; Jeffrey Legro and Andrew Moavcsik, 'Is Anybody Still a Realist?', *International Security*, vol. 24, no. 2, p. 5. Although looking at it from a differing perspective can mean that 'The competing predictions of realist theories make realism difficult to falsify. Almost any outcome can be made consistent with some variant of realist theory. Richard Ned Lebow, 'The Long Peace, the End of the Cold War, and the Failure of Realism', *International Organisation*, vol. 48, no. 52, 1994, p. 250. See also Michael C. Williams, 'Why Ideas Matter in International Relations: Hans Morgenthau, Classical Realism, and the Moral Construction of Power Politics', *International Organization*, vol. 58, no. 4, 2004, pp. 659-60.

[48] Jervis, *System Effects*, p. 108. See Bull, *The Anarchical Society*, passim.

[49] Vasquez, 'World Politics Theory', p. 854.

[50] Clark, *Reform and Resistance in the International Order*, p. 28.

[51] To refresh: Class I were 'doomsday' rules and die within two moves and are considered dead, class II are marginally better and, after the planting of the initial 'seed', quickly form static, pulsating blobs, or in others words they appear highly ordered. See Waldrop, *Complexity*, esp. pp.224-235, 292-294.

remain. An order is still present.[52] Most rationalist-based theories have difficulty accounting for this. During the Cold War, the world, from the Western perspective, appeared relatively stable. The dynamics that define a complex system were muted, complex dynamics were present but the patterns were 'rendered redundant due to the inability to conceive its dynamics'.[53] Uncertainty is a part of what it is to be human, and, indeed, to be alive. Consequently, with this in mind, politics, in its many forms, should not be imagined as being outside of a paradigm of uncertainty. Order cannot be 'taken as an objective condition'.[54] Yet, it cannot be understated that 'patterns of linear causality … still seem to inform dominant IR approaches'.[55] This is not to dismiss what has been written by those who belong to the rationalist schools; there is no intent nor necessity for this to occur. The central argument is to displace the Newtonian paradigm so that an alternative non-linear foundation can inform or re-inform those approaches. For example, E.H. Carr was certainly insightful when he noted that 'power is a necessary ingredient of order', and from it has emerged a basic realist tenet that cannot be ignored.[56] However, it is not the only ingredient, and nor should it be considered peculiar to realism. The difficulty lies in the insistence of taking both order and power as 'objective condition[s]'. But even if taken as the dominant currency in international rations, the nature of that currency is dependent on how it too is conceptualised. Neither anarchy nor power can sit outside, or be removed from, paradigmatic influences.

---

[52] Rosenau, *Turbulence in World Politics*, pp. 52-3. Turbulence, for Rosenau, consists of the fluctuations 'that make up the day-to-day life of any system' and to study it 'is to analyze responses to uncertainty'. Under turbulent conditions situations can 'develop rapidly as the repercussions of the various participants' actions cascade through their networks of interdependence'. ibid., pp. 8, 11.

[53] Kavalski, 'Emergence of Complex International Relations Theory', p. 442. However, it is worth mentioning that nuclear weapons, far from bringing stability, merely pushed 'international conflict into new and diverse formats' encapsulated by the rather perverse notion of Cold War 'sideshows'. Roger Beaumont, *War, Chaos, and History*, Praeger, Westport and London, 1994, p. 167.

[54] Onuf, *World of Our Making*, p. 155.

[55] Kavalski, 'Emergence of Complex International Relations Theory', p. 435. This, of course, raises the dilemma of whether or not non-linear approaches, when utilised in a shallow and analogous manner, are just reflecting a desired ontological perspective.

[56] Carr, *The Twenty Years' Crisis*, p. 213.

Power and Persuasion

Power is not easily defined.[57] Steven Lukes correctly surmises that the 'possession of power… depends on the truth of certain subjunctive conditionals',[58] adding to the complexity of any attempt to convey a neat and to the point definition. David Singer, ignoring such concerns, merely defines power as the ability to influence.[59] Niccolò Machiavelli felt little doubt when he stated that 'politics is the science of power'.[60] Bertrand Russell, similarly, does not drift too far from this sentiment. For Russell, power is a fundamental concept of the social sciences. Indeed, he felt that power is to the social sciences what energy is to physics.[61] The study of international relations is no different. Realist, statist and structuralist notions of power dominate and are often construed as the simplest, most succinct and common-sense approach to understanding the relations between states. For Hans Morgenthau, 'international politics, like all politics is a struggle for power'.[62] He continues:

> Whatever the ultimate aims of international politics, power is always the immediate aim. Statesmen and peoples may ultimately seek freedom, security, prosperity, or power itself. They may define their goals in terms of a religious, philosophic, economic, or social ideal. They may hope that this ideal will materialize through its own inner force, through divine intervention, or through the natural development of human

[57] As with any such broad fitting term the temptations exists to do away with the term in its entirety, replacing it with numerous qualified sub-headings that may capture the dynamics of power of the myriad of social relationships that influences, drives and is a product of. Yet to abandon it would remove the possibility for social scientist to compile small order concepts into a coherent whole. John Gerring, 'What Makes a Concept Good? A Critical Framework for Understanding Concept Formation in the Social Sciences', *Polity*, vol. 31, no. 3, 1999, p. 359. Lukes has also noted that the difficulty in the defining power stems from it being a '*primitive*'. By this he means 'that its meaning cannot be elucidated by reference to other notions whose meaning is less controversial than its own'. He adds that '"Truth" is another such concept'. Steven Lukes, 'Power and the Battle for Hearts and Minds: On the Bluntness of Soft Power' in Felix Berenskoelter and Michael J. Williams, eds, *Power in World Politics*, Routledge, Abingdon, 2007, p. 83.

[58] Steven Lukes, 'Introduction' in Steven Lukes, ed., *Power*, Basil Blackwell, Oxford, 1986, p. 16.

[59] Charles McClelland, 'Power and Influence', in John R. Champlin, ed., *Power*, Atherton Press, New York, 1971, p. 52.

[60] Dorothy Emmet, 'The Concept of Power' in John R. Champlin, ed., *Power*, Atherton Press, New York, 1971, p. 79. Russell also saw power as 'the production of intended effects'. Russell quoted in Lukes, 'Power and the Battle for Hearts and Minds', p. 84

[61] Bertrand Russell, *Power: A New Social Analysis*, Allen and Unwin, London, 1983 [1938], p. 9. See also Emmet, 'The Concept of Power', p. 79.

[62] Morgenthau, *Politics Among Nations*, p. 25; and, 'Indeed, to engage in such disputes [about power] is itself to engage in politics' Steven Lukes, *Power: A Radical View*, Macmillan, London, 1974, p. 26.

> affairs. They may also try to further its realization through nonpolitical means, such as technical co-operation with other nations or international organizations. But whenever they strive to realize their goal by means of international politics, they do so by striving for power. The Crusaders wanted to free the holy places from domination by the Infidels; Woodrow Wilson wanted to make the world safe for democracy; the Nazis wanted to open Eastern Europe to German colonization, to dominate Europe, and to conquer the world. Since they all chose power to achieve these ends, they were actors on the scene of international politics.[63]

Morgenthau was quick to note that power in the international setting is not easily calculated, resulting in states always attempting to maximise their relative power in comparison to other states.[64] Charles McClelland is less concerned with domestic and international divide when considering the accumulation of power. For him, 'success of a man or an organisation depends on the possession of accumulated power greater than the amounts of power held by opponents'.[65] McClelland draws on Morgenthau (and both draw on an unstated and possibly unrealised commitment to the behavioural sciences) to support his argument that 'political power is a psychological relationship between those who exercise it and those over whom it is exercised'.[66]

The first two of Lukes's three dimensions of power emerge strongly through these definitions. The first two dimensions deal with the power infused through raw capabilities and the ability, through influence, to get an agent to do something

[63] Morgenthau, *Politics Among Nations*, p. 25.

[64] ibid., pp. 200, 202. This is the core of classical realism's power maximisation thesis that is tied to essential idea of human nature vis-à-vis agency (which can, in turn, be tied to notions of original sin). On sin and human nature see the seminal text by Reinhold Niebuhr, *Moral Man and Immoral Society: A Study in Ethics and Politics*, Westminster John Knox Press, Louisville, 2002 [1960]. In the introduction, Langdon B. Gilkey writes that 'Niebuhr sought in this work to reinterpret in a modern fashion – in the light of modern scientific and historical understanding – the old and somewhat abandoned symbols of sin and even of original sin'. ibid., p. xiii. See also Waltz, *Man, the State and War*, pp. 20-1. In terms of state agency, neorealism, according to Waltz, argues that states only seek security. However, as Wendt points out, Waltz may well want 'to get away from such a dubious psychology, but rather than leave psychology behind he simply substitutes a different one. Wendt also notes that Morgenthau's states are by nature aggressive and opportunistic, Waltz's defensive and cautious', Wendt, *Social Theory of International Politics*, p. 105.

[65] McClelland, 'Power and Influence', p. 35.

[66] ibid., pp. 43-4. See Morgenthau, *Politics Among Nations* p. 27. Morgenthau continues his point stating that 'It gives the former control over certain actions of the latter through the influence which the former exerts over the latter's mind'. ibid.

they would not ordinarily do. A one-dimensional view of power is evident, where 'power offers a clear-cut paradigm … of decision making power by political actors'.[67] Robert Dahl expounded the value of this interpretation with his much-quoted definition of power: 'A has power over B to the extent that he can get B to do something that B would not otherwise do'.[68] This conception of brute capabilities is often attached to realism, particularly the offensive realism of John Mearshiemer.[69] However, Lukes argues that such a mono-dimensional conception 'takes over the bias of the political system … and is blind to the ways in which its political system is controlled', meaning that it is limited in its enquiry.[70] Russell categorises power a little differently, by identifying three classifications: that of direct physical power, power mitigated through reward or punishment, and the power of influence and opinion.[71] Russell's three distinct forms of power move the debate into the realm of what Lukes calls two-dimensional power.[72] Coercion, in order to achieve compliance, is portrayed as being as important as brute power.[73] With the extra categorisations, the argument is that 'non-decision making is a form of decision making' and that the second dimension of power allows '*potential issues* which non-decision-making prevents from being actual' to be identified.[74] Yet, for Lukes, a significant obstacle in this model is that it fails to include non-participants; those who are apathetic,[75] removed, or unaware as to how they may

---

[67] Lukes, *Power: A Radical View*, p. 57.
[68] Clarissa Rile Hayward, 'De-facing Power', *Polity*, vol. 31, no. 3, 1998, p. 3.
[69] See John J. Mearsheimer, *The Tragedy of Great Power Politics*, W. W. Norton & Company, New York and London, 2003, esp. pp. 4-11, 17-22.
[70] Lukes, *Power: A Radical View*, p. 57.
[71] Bertrand Russell, 'The Forms of Power' in Steven Lukes, ed., *Power*, Basil Blackwell, Oxford, 1986, p. 19. The typology that Lukes borrows for his idea of the second dimension embraces coercion, influence, authority, force and manipulation. Lukes, *Power: A Radical View*, pp. 16-20.
[72] Lukes, *Power: A Radical View*, ch. 3. This can involve differing permutations, for example, Keohane and Nye present a two-dimensional view of a networked conception of power that takes sensitivity and vulnerability into consideration. Robert O. Keohane and Joseph S. Nye, *Power and Interdependence*, 3rd ed., Longman, New York, 2001, pp. 10-11, 235-8.
[73] Stephen Krasner's argument of the manner in which the sovereignty of the state may be breached is bound this second dimensional view of power. For Krasner the four possibilities are tied to 'Conventions, contracts, coercion, and imposition' Krasner, 'Rethinking the Sovereign State Model', pp. 18, 23-34 For instance, in a later work, Lukes notes the George W. Bush administration's refusal to ratify the 'Kyoto protocols on climate change and not participating in the International Criminal Court' as a show of power. Lukes, 'Power and the Battle for Hearts and Minds', pp. 85-6.
[74] Lukes, *Power: A Radical View*, p. 19. Here Lukes draws on the work of Bachrach and Baratz.
[75] On the apathetic, obviously in the domestic setting, C. Wright Mills, made reference to such 'inactionary' types as idiots. Mills was, of course, referring to the Greek definition of 'an altogether private man' before

be affected. The two-dimensional view, as argued by Lukes, lacks a thorough sociological perspective' as it limits the effects and influences to those directly caught up in the power play.[76] From this developed the third dimension; one that was heavy in Marxist determination.[77] Hayward summarises before offering Lukes's own definition:

> According to Lukes's 'three dimensional' account, power not only can influence whether actors behave as they want and determine whether they participate in politics to express their preferences, but also can shape the ways they perceive their wants, desires, and interest. '*A* exercises power over *B* when *A* affects *B* in a manner contrary to *B*'s interests.'[78]

In essence, Lukes added the third dimension of desires, wants, interests and ideology; the difficulty being that it was all much harder to quantify, leading to claims that Lukes had led the debate into the realm of metaphysics.[79] Effectively, his third dimension is about domination, a realm that Lukes felt was the 'most insidious and important form of power'.[80] The study of international relations through the rationalist lens, however, is primarily concerned only with overt forms of domination, as characterised by the first two dimensions,[81] and not with what Lukes would refer to as the suppression of 'latent conflicts'.[82] Lukes recognises the individualistic and atomised nature of power when only held in the

---

attributing the 'current malaise' in society to those who are 'disengaged' from the political system. C. Wright Mills, *The Sociological Imagination*, Penguin Books, Harmondsworth, 1958, p. 51.

[76] Lukes, *Power: A Radical View*, p. 57.

[77] Hayward, 'De-facing Power', p. 4. Take the sentiment; 'Is it not the supreme and most insidious exercise of power to prevent people, to whatever degree, from having grievances by shaping their perceptions, cognitions and preferences in such a way that they accept their role in the existing order of things, either because they can see or imagine no alternative to it, or because they see it as natural and unchangeable, or because they value it as divinely ordained and beneficial?' Lukes, *Power: A Radical View*, p. 24.

[78] Hayward, 'De-facing Power', p. 4.

[79] ibid.

[80] Lukes, *Power: A Radical View*, p. 24; Keith Dowding, 'Three Dimensional Power: A Discussion of Steven Lukes's *Power: A Radical View*', *Political Studies Review*, vol. 4, no. 2, 2006, p. 137. Lukes breaks town his third dimension of power as such: '1. decision-making and control over political agenda (not necessarily through decisions) 2. issues and potential issues 3. observable (overt or covert) and latent conflict 4. subjective and real interests', Lukes, *Power: A Radical View*, p. 25. Dowding highlights what arise from an examination of three dimensional power: 'Several aspects of domination in the third dimension are important. First is the status of values, preferences, interest, beliefs and desires. Second, given their status, in what form can we criticise these objects? Third, there are queries over the dominant-dominated relationship. Is everyone who gains at the expense of others dominant? Fourth, there is the question of responsibility. Must the dominant need to know what they are doing or can their privilege be a by-product of forces they do not understand?', Dowding, 'Three Dimensional Power', p. 137.

[81] Brown, *Understanding International Relations*, p. 82

[82] Lukes, *Power: A Radical View*, p. 57.

first and second dimension.[83] This, of course, suits a state-centric conceptualisation of the international system,[84] yet it denies the role of self-organisation and feedback to the emergence of different structures. Effectively, this conceptualisation of power is reductionist. However, if power is moved to the third dimensions it pushes beyond interests, influence and capabilities and allows for a systemic idea of power to emerge. Indeed, 'when systemic power operates not only in a repressive fashion but also by shaping norms and preferences, it is possible that neither A nor B are aware of what their interests are'.[85] An international society of differing and multiple power relations begins to emerge.

The issue here is to not 'fall into the Foucaultian trap'.[86] This '"ultra-radical" view of power', suggests that power produces, controls and constitutes the formation of agents,[87] surrendering agency to an amorphous relativism. Although offering important insights, it is necessary, as one author puts it, to avoid succumbing 'to the sirens of poststructuralism'.[88] Instead, it should be recognised, that despite the reasons for actions of agents not always being 'conscious nor recognisable to them',[89] a core notion of what is real can be 'unconcealed'.[90] Here, Keith Dowding emerges as an unlikely ally of Lukes's conception of the third dimension, insofar as it adheres to an 'intentional stance',[91] which, in certain respects, is a return to Lukes's own admission that 'his account of power is essentially contested because

[83] Torben Bech Dyrberg, *The Circular Structure of Power: Politics, Identity, Community*, Verso, London, 1997, p. 67.
[84] This does not always mean that there will always be a simplistic understanding. Take Jervis, a realist who utilises complexity theory, who states that 'simple and straight forward ways of proceeding will rarely suffice because power constitutes a relationship among actors who formulate goals on the basis of what they think is possible and who act on estimates of how they think others will respond.' Jervis, *System Effects*, p. 74.
[85] Dyrberg, *The Circular Structure of Power*, p. 67.
[86] Dowding, 'Three Dimensional Power', p. 186.
[87] Lukes, 'Power and the Battle for Hearts and Minds', pp. 96-7.
[88] Stefano Guzzini, 'A Reconstruction of Constructivism in International Relations', *European Journal of International Relations*, vol. 6, no. 2, 2000, pp. 147-48.
[89] Dowding, 'Three Dimensional Power', pp. 136-7. It is important to stress that 'For Foucault, domination 'is only one form of power relation''. Hayward, 'De-facing Power', p. 21.
[90] A critical realist framework would dovetail well to this notion. See Chapter Five.
[91] Dowding, 'Three Dimensional Power', p. 143. This 'requires an externalist account of the human mind', ibid.

it requires a notion of objective interests'.[92] Yet despite this contested area, it is here that 'individual rationality tends to be undermined'; that is, agents cannot be considered wholly autonomous, due to whatever power relationship an agent is subjected to.[93] In essence, Lukes's dimensional view of power becomes trapped between agency and structure. Power is attributed to agents in the first and second, and in the third it is delivered to the structure. A non-linear understanding offers a release, as it 'transcends the division between free will and determinism and hence between agency and structure.'[94] Whilst still maintaining a distance from a reformulated Foucaultian position, it is still important to recognise that power is not a linear concept and that it has no *telos*.[95] Putting all this together, it can be stated that any attempt to conceptualise of power as mono-causal, linear and additive within a deterministic framework will mislead. This is because:

> Autonomy and rationality are the irreducible opposites of power, which are posed or delineated by power strategies whilst also trying to escape their grip by virtue of being presupposed as given faculties, which power tries to rasp from the 'outside'… Here we find an inescapable circularity that pertains to space and time which various conceptions of power, irrespective of whether they are rooted in agency or structure, try to make linear. The aim is of course, to render power a causal concept that operates in accordance with 'the canons of science'…[96]

---

92 ibid., pp. 137-8. Lukes states 'both its very definition and any given use of it, once defined, are inextricably tied to a given set of (probably unacknowledged) value-assumptions which predetermine the range of its empirical application', Lukes, *Power: A Radical View*, p. 26..

93 Dyrberg, *The Circular Structure of Power*, p. 68. Hayward reaches a conclusion that is not incommensurable, even when presenting an argument of the necessity of intentionality, as she concedes that 'one might envision a continuum of power relations on which domination forms one endpoint. At the opposite end would be the fluid power relation defined by social boundaries that are understood by all participants and that allow the maximum possible space, not only for action within, but also for effective action upon the boundaries themselves.' Hayward, 'De-facing Power', p. 21.

94 John Urry, *Global Complexity*, Polity Press, Cambridge, 2003, pp. 111-12.

95 Dyrberg, *The Circular Structure of Power*, p. 117. It is worth highlighting that approaches informed by complexity theory will generally (or should) deny teleological claims, indeed, part of the problem for many social and political theories is that there often exists an 'advanced or final stage… to which all change is directed'. T.R. Young, 'Chaos Theory and Social Dynamics: Foundations of a Post modern Science' in Robertson and Combs, eds., *Chaos Theory in Psychology and the Life Sciences*, Lawrence Erlbaum Associates, New Jersey, 1995 p. 217. Moreover, rooted in reductionism is the teleological desire for a 'final theory' or a 'theory of everything'. Kauffman, *At Home in the Universe*, p. 16. This is not to say that final cause, in the Aristotelian sense, cannot be pursued. Final cause is 'fundamentally different' from any teleological claims and 'is the basis for the recognition of *anticipation* in complex systems'. Mikulecky, 'The emergence of complexity', p. 347.

96 Dyrberg, *The Circular Structure of Power*, p. 246.

Science, in its reductionist guise, captured power as a causal explanation for the interaction between its axioms. Although Russell attempted to step away from nineteenth century positivist causality, his conception of power as analogous as energy is to physics holds true to its Newtonian roots.[97] Yet, a non-linear account accepts that power is neither a steady state, as seen in equilibrium-based notions of balance of power, nor is it periodic, as it is conceived by cyclical theories of power.[98] Power through a non-linear lens resembles chaotic phenomena.[99] Conceptually, it can be imagined as a strange attractor that attracts to a series of points, never the same but patterned nonetheless.[100] An account of the continual evolution and emergence of power through a non-linear perspective is built on the interactions between states, which push systems in a manner that is not captured by equilibrium or cyclical theories.[101] How, then, should power be understood for the study of international politics? If power is more than brute force, influence and opinion of agents involved, or, conversely, if it does not sit well in a structural top-down approach, how then must it be conceptualised? The first step is to divorce the concept of power as a defining attribute of realism. As Wendt argues:

> The proposition that the nature of international politics is shaped by power relations invariably is listed as one of the defining characteristics of Realism. This cannot be a uniquely Realist claim, however, since then every student of international politics would be a realist. Neoliberals think power is important, Marxists think power is important, postmodernists even think it is everywhere.[102]

Wendt continues and successfully captures the important distinction of how power is constituted depending upon the theoretical outlook:

---

[97] Russell, *Power: A New Social Analysis*, p. 11. At least within the popularly held scientific imagination; conceivably, there is room for radical reinterpretation of the analogy via a quantum lens.

[98] Diana Richards, 'A Chaotic Model of Power Concentration in the International System', *International Studies Quarterly*, vol. 37, no. 1, 1993, pp. 56-8. Dryberg's circular notion of power largely sidesteps the criticism of 'cyclical theories of power' because of his emphasis of the dualism of agency and structure and the consequent irreducibility of power (and the inevitability of power). See Dyrberg, *The Circular Structure of Power*, pp. 1-12.

[99] Richards, 'A Chaotic Model of Power Concentration in the International System', pp. 56-8. Diane Richards recognises the power, via a chaotic understanding, embodies a 'fractal dimension'. ibid., p. 59.

[100] ibid.

[101] ibid., p. 63.

[102] Wendt, *Social Theory of International Politics*, pp. 96-7.

> Better instead to differentiate theories according to *how power is constituted*. From this perspective the distinctively Realist claim is the materialist hypothesis that the effects of power are constituted primarily by brute material forces. The rival idealist hypothesis is that power is constituted primarily by ideas and cultural contexts.[103]

Although primarily still focussed on constituting power via the first two dimensions, the idea that power is driven by 'ideas and cultural contexts' is built on the breakdown of the agent structure divide and accepting the inter-subjectivity of any power claims. This is a non-linear conceptualisation of power derived from a chaotic understanding. Chaos does not refer to the descent into Hobbesian anarchy, but refers to 'the concentration and distribution of power' that, as part of any emergent phenomenon, will continue to evolve as it constantly readjusts and re-informs. This fluidity is the result of its sensitivity to initial conditions, with 'future distributions' always being 'difficult to predict on current conditions and trends'.[104] This is an admission that power cannot be distilled, and that the study of international relations needs to focus on *relationships*, and it must extend beyond the conceptualisation that they only exist in terms of power.[105] However, much of IR theory, which often draws from a rationalist base, considers power, in its reductionist sense, as the causal link between the respective Newtonian and universal worlds. Essentially, it is one of the major building blocks when devising a science of international relations.

---

[103] ibid., p. 97. It is also important to not misrepresent Wendt who feels 'that Power and interests are just as important and determining as before. The claim is rather that power and interests have the effects they do in virtue of the ideas that make them up. Power and interest explanations *presuppose* ideas, and to the extent are not rivals to ideational explanations at all.' ibid., p. 135. And, in short, 'constitutive theorists have shown how phenomena normally seen as material, such as power, are in fact constituted by ideas'. Wendt, 'Why a World State is Inevitable', p. 495.

[104] Richards, 'A Chaotic Model of Power Concentration in the International System', p. 56.

[105] Vasquez, *The Power of Power Politics*, p. 380. Here Vasquez builds on the earlier work of John Burton. See John W. Burton, A.J.R. Groom, Chris R. Mitchell, and A. V. S. de Reuck, *The Study of World Society: A London Perspective*, Occasional Paper No. 1 International; Studies Association, 1974 and John W. Burton, *Conflict: Resolution and Provention*, Macmillan, Basingstoke, 1990. On the latter title, Burton writes on the necessity of value relationships, although this primarily seems to be aimed at relationships between the individual and society. ibid., pp. 46-7, 80-2 153-6. In his earlier 1972 publication *World Society*, Burton makes it clear that 'the study of world society in not confined to relations among states or state authorities. There are important religious, language, scientific, commercial and other relationships in addition to a variety of formal, non-governmental institutions that are world-wide.' John W. Burton, *World Society*, Cambridge University Press, Cambridge, 1972, p. 19.

The Science of International Relations

Kenneth N. Waltz, one of the most significant figures in IR theory literature, has a concrete idea as to what correct theory construction should entail. Scathing of those theories that he feels do not adhere to appropriate methods, the father of structural realism nailed his scientism to the door when he revealed in an interview that:

> There are all kinds of theory. There's the theory of literary criticism. And that obviously has to be a very different thing; I would not use the term theory for it. There's international political theory, there's feminist theory. Indeed there was a recent conference at USC held under the rubric 'Woman, the State, and War'. One can't legislate. People use 'theory' in all sorts of different ways. All I claim is that I do make clear how I use that term. And my usage has a good pedigree in the natural sciences, economics and much of the philosophy-of-science literature.[106]

Stephen Walt recognised that 'all the complexity of contemporary world politics' cannot be captured by a single approach.[107] Yet Waltz, by narrowing his conception of the correctness of theory construction, embodies a pseudo-scientific approach that denies theory-building can appropriately occur from a non-scientific base. The base is, of course, the linear Newtonian paradigm that underscores rationalist-based theories that predominately reduce to fundamental units. As Rosenau points out, with respect to the ease and simplicity of such theory-building:

> One can be envious of those analysts who are able to account for the course of events by positing all actors as egoistic power maximizers [Kenneth A. Oye], or can reduce modern

[106] Halliday and Rosenberg, 'Interview with Ken Waltz', p. 384. On feminism in particular Waltz is far from overwhelming in his praise when he says that 'Feminists offer not a new or revised theory of international-political theory but a sometimes interesting interpretation of what goes on internationally', ibid., p. 387.

[107] Walt, 'One World, Many Theories', p. 30. Walt points to the limitation of realism as an inability to 'account for international change', of the tendency of liberalism 'to ignore the role of power', and of constructivism being a theory of hindsight as opposed to possessing any real ability to anticipate future events. ibid. p. 38.

> international history to a clash between security and economic interests [Richard Rosencrane], or who can ascribe all causation to the structural requirements of the global capitalist economy [Immanuel Wallerstein], or who can use the requirements imposed by the state system to cast a wide explanation net [Kenneth Waltz], or who explain the long cycles of war of one or another master variable [Joshua S Goldstein].[108]

Much earlier, Bull had written on the unfortunate inroads scientific enquiry had made into the discipline, lamenting that within a decade the study of international politics as a science had moved from a 'fringe activity' to the 'orthodox methodology'.[109] Nicholas Rengger notes that by the 1950s much of the 'traditional language' was expunged from the study of international relations while 'scientific' and 'explanatory' approaches took hold.[110] The language of science, how it was imagined within a social science context quickly subsumed ontological, epistemological and methodological assumptions in a manner previously not seen within the new discipline. Because of this, wariness is needed when examining IR theory, particularly in the American configuration that make broad claims that are more often than not 'unexamined assumptions' that:

> constitutes a set of reflections on the appropriate investigative techniques for a discipline with permanent ontological features, a distinct subject matter separate from other fields, and a subject amenable to the general characteristics of natural science.[111]

---

[108] Rosenau, *Turbulence in World Politics*, p. 23. The examples are Rosenau's, each footnoted in the original text.

[109] Bull, 'International Theory: The Case for a Classical Approach', p. 363. On the accessibility of such an approach Bull does not dismiss it, but he certainly points out that a 'complaint made of these theorist, especially, perhaps, of Morton Kaplan's, is that their writing is tortuous and inelegant' (He qualifies the remark that one doesn't dismiss the work of Einstein because of the 'difficulty of reading') ibid., p. 364. And from this, realism's dominance, which Vasquez places as a paradigm, with its base assumptions, became widely accepted in the United Kingdom and the United States from the beginning of the 1950s. Vasquez, *The Power of Power Politics*, p. 38. Beyond the classical realism of Morgenthau, Carr and Keenan, Vasquez argues, that from 'the late 1950s and the early 1960s the behavioural revolt began to make its influence felt. Among the first major scholars reflecting this new emphasis were Morton Kaplan and Karl Deutsch. Their work reflected the three main characteristics of the new approach: a concern with the philosophy of science; an attempt to borrow from the physical and more "developed" social sciences; and an attempt to apply mathematical, particularly statistical, analysis to international relations inquiry.' ibid., p. 40. This further fanned the flames of a scientific and economic ontology.

[110] Nicholas Rengger, 'Political Theory and International Relations: Promised Land or Exit From Eden?', *International Affairs*, vol. 76, no. 4, 2000, p. 756.

[111] Robert M. A. Crawford 'Where Have all the Theorists Gone?' in Robert M. A. Crawford and Darryl S. L. Jarvis, *International Relations – Still an American Social Science: Towards Diversity in International Thought*, State University of New York Press, Albany, 2001, p. 227. Crawford continues: 'What Brown calls

For Bull, the obsession with 'intellectual Puritanism', stripping away all that was unnecessary, committed those who pursued a scientific understanding to a course of study that was so removed 'from the substance of international politics as the inmates of a Victorian Nunnery were from the study of sex'.[112] Scientific modelling particularly caught Bull's ire, as its 'very intellectual completeness and logical tidiness of the model-building operation lends it an air of authority which is often quite misleading as to its standing as a statement about the real world'.[113] For much the same reasons, Hans J. Morgenthau was an ardent critic of the '"pseudo-scientific rationalism" with its desire, captured by the incessant model making [to discover] an order analogous to the order perceived in the natural world'.[114]

However, the impact of science on the field of IR has a subtlety that extends beyond the hard and direct application that occurred during the so-called second debate.[115] Paradigmatically, science was far more insidious, and many of the traditionalists who opposed the influx of direct scientific methodologies were not free from the reach of the dominant scientific worldview. Morgenthau, 'who was vigorously opposed to scientization in IR', is attached and despite protestation *was*

---

international relations theory (and might be just happy to call social-political theory) is much more fluid, and premised on a rejection of IR theory's hypothesized autonomy from political and social thought, philosophy, history, public law, cultural studies, and a variety of other field's whose insight may prove relevant and useful to the study of world politics.' ibid.

[112] Bull, 'International Theory: The Case for a Classical Approach', p. 366.

[113] ibid., pp. 370-1. And, as Nicholas Rengger argues, of implicit Newtonian methods, that 'We cannot have a 'science' of international politics (any more than we can have a 'science' of politics) simply because politics (and international politics) are a realm of human conduct where the voice of science is inappropriate.' Nicholas Rengger, 'Realism, Tragedy, and the Anti-Pelagian Imagination in International Political Thought' in Michael C. Williams, ed., *Realism Reconsidered: The Legacy of Hans J. Morgenthau in International Relations*, p. 132.

[114] Molloy, 'Truth, Power, Theory: Hans Morgenthau's Formulation of Realism', pp. 2-3.

[115] The second debate see: Morton A. Kaplan, 'The New Great Debate: Traditionalism vs. Science in International Relations', *World Politics*, vol. 19, no. 1,1966, pp. 1-20. The constant clamouring for debates in IR becomes tiresome, often they are reflective a much broader schism in the many disciplines that the field draws. Yet what is more concerning in the progressive gradualism inherent in the idea of moving from first, second, third and even fifth debates. See, for example, Emmanuel Navon, 'The 'Third Debate' Revisited', *Review of International Studies Revisited*, vol. 27, no. 4, 2001, pp. 611-625. As an example Navon notes that Vico's debate on human nature that 'man as he is' versus 'man as he should be' is the continued 'oscillation' of a debate that can be traced to pre-Socratic times. To suggest that IR is done and dusted on that issue and has moved on from its 'first debate' is ridiculous. ibid., pp. 612-3. On the emergence of a possible fifth debate (and from a complexity theory perspective) see Kavalski, 'Emergence of Complex International Relations Theory', pp. 435-54.

a 'progenitor' of the influence of science in the discipline.[116] In essence, the search for evidence, particularly by realists 'for timeless descriptive and prescriptive laws linking power, survival and national interests',[117] reflected, however implicitly, 'the growing and conceptual power of natural science'[118] that had spilled from the nineteenth century.

Morgenthau's outlook, however unfairly,[119] is often depicted as proto-scientific, with his axiomatic six principles and his most famous of statements that the 'struggle for power' lies at the heart of all politics. From it came the assumption that the state was *the* unit of the system and that it was forever caught in this struggle. It was an inescapable 'iron law of politics'.[120] In developing his 'fundamental principles' of international relations, Morgenthau was, in his own words, creating a 'science of international politics'. Further still, it was a science of reductionism;[121] that is, it sought axioms from which all else could be built and understood. Morgenthau's law-making, despite his philosophical roots, attaches itself to reductionist science, this being a part of his first principle:

> Realism, believing as it does in the objectivity of the laws of politics, must also believe in the possibility of developing a rational theory that reflects, however imperfectly and one-sidedly, these objective laws. It believes also, then, in the possibility of distinguishing in politics between truth and

---

116 This is to change the emphasis of Seán Molloy's argument who rightly, in context of directly introducing science *á la* Kaplan or Waltz, defends Morgenthau (Molloy's original quote runs: ''It is a rich irony that Morgenthau, who was vigorously opposed to scientization in IR, is portrayed by Vasquez as the progenitor of the scientific wing of the discipline'), Molloy, 'Realism: A Problematic Paradigm', p. 79. It is worth noting the further irony that 'Vasquez is the most strident 'scientific' critic of realism in IR'. ibid., p. 71.

117 Hayward R. Alker, Jr. and Thomas J. Biersteker, 'The Dialectics of World Order: Notes for a Future Archaeologist of International Savoir Faire', *International Studies Quarterly*, vol. 28, no. 2, 1984, pp. 124-5. Butterfield notes the contingent nature of such laws. Hebert Butterfield, *International Conflict in the Twentieth Century: A Christian View*, Routledge and Kegan Paul, London, 1960, p. 53.

118 Rengger, *International Relations, Political Theory, and the Problem of Order*, p. 8.

119 As Richard Little notes, the subtlety of Morgenthau *Politics Among Nations* is often underappreciated and often his text is all too eagerly trawled through so as to expose his reductionist tendencies (and claims of biological realism). Richard Little, 'The Balance of Power in *Politics Among Nations*' in Michael C. Williams, ed., *Realism Reconsidered: The Legacy of Hans J. Morgenthau in International Relations*, Oxford University Press, Oxford, 2007, p. 137. Indeed, Morgenthau, quoting from Montesquieu's *Spirit of the Laws*, request of his readers specifically not to undertake such a tasks; 'I beg one favour of my readers… that they will not judge by a few hours' reading of the labour of twenty years; that they will approve or condemn the book entire, and not a few particular phrases'. Morgenthau, *Politics Among Nations*, p. xiii.

120 Charles A. McClelland, *Theory and the International System*, Macmillan, New York, 1967, p. 64.

121 Gaddis, 'International Relations Theory', p. 7.

> opinion-between what is true objectively and rationally, supported by evidence and illuminated by reason, and what is only a subjective judgment, divorced from the facts as they are and informed by prejudice and wishful thinking.[122]

This is not to suggest that Morgenthau was inflexible in respect to how he saw the international system. On the permanency of the state, he did not, despite many assuming to the contrary, consider it an immovable and permanent feature of the international system and noted the dual, yet contradictory, process of increasing fragmentation and amalgamations.[123] However, for Morgenthau the 'fundamental impulses to power and order' do not change when transforming 'the political system from simple power politics to complex power politics'.[124] Caught in the first and second dimension, the axiomatic nature of power is immutable. It is here that power and notions of science meld. Human nature, the 'will to power',[125] and science are bound in his first principle which begins with the declaration that:

> Political realism believes that politics, like society in general, is governed by objective laws that have their roots in human nature. In order to improve society it is first necessary to understand the laws by which society lives. The operation of these laws being impervious to our preferences, men will challenge them only at the risk of failure.[126]

Essentially, Morgenthau's 'six principles of political realism', first listed in the second edition of *Politics Among Nations*,[127] captures an essence of axiom-based

---

[122] Morgenthau, *Politics Among Nations,* p. 4.
[123] Morgenthau never conceived the state to be eternal and saw it as a construction. Moreover, he moved towards thinking about the world 'in terms of a supranational community and a world government, a political organisation and structure that transcend the nation state.' Morgenthau quoted in Cozette, 'Reclaiming the Critical Dimensions of Realism: Hans J. Morgenthau on the Ethics on Scholarship', p. 20. See also Morgenthau, *Politics Among Nations*, p. 9, where he states 'While the realist indeed believes that interest and the national state is a product of history, and is therefore bound to disappear in the course of history. Nothing in the realist position militates against the assumption that the present division of the political world into nation states will be replaced by larger units of a quite different character, more in keeping with the technical potentialities and the moral requirements of the contemporary world.'
[124] Molloy, 'Truth, Power, Theory: Hans Morgenthau's Formulation of Realism', p. 27.
[125] Patomäki and Wight, 'After Postpositivism?', p. 222.
[126] Morgenthau, *Politics Among Nations*, p. 25.
[127] Anthony F. Lang Jr., 'Introduction' in Hans Morgenthau, *Political Theory and International Affairs: Hans J Morgenthau on Aristotle's the Politics*, ed. Anthony F. Lang Jr., Praeger, Westport, 2004 , p. 3. In fact the likes of Kenneth Waltz and John Vasquez claimed him to not be scientific enough. ibid. For Waltz,

reductionism and law-like generalisation associated with an attempt to create a science of international relations.[128] Indeed, it is difficult to escape the title of his second chapter, 'The Science of International Relations',[129] as a commitment to a scientific outlook. Yet Colin Wight asserts that to conflate this as an admission 'to a commitment to scientific IR is to miss the point'.[130] And, to *a* point Wight is correct. It was not necessarily a considered commitment to the pseudo- or social 'scientificism'[131] that was creeping into the study of IR. Moreover, Morgenthau's conception of science reflects his Aristotelian view of science (and, with it, the idea of truth), which differs significantly from the empirical and evidenced-based science that has emerged in modern times.[132] Sean Molloy argues similarly in that:

> Morgenthau has a very particular notion of what constitutes 'science,' which rests on a distinction between being rational as opposed to rationalistic – unsurprisingly, given his background and training, Morgenthau's political science was derived from the German understanding of science as *Wissenschaft* and was essentially hermeneutic rather than 'scientific' in the Anglo-American understanding of that word. If political cynicism and scepticism are the keys to understanding international relations, the role of scientific analysis is to prune down national objectives to the measure of available resources. [133]

Morgenthau 'turned toward history and [was] concerned more with policy than with theory and scientific methods'. Waltz, *Theory of International Politics*, p. 63.

[128] For an interesting account of one of the earlier attempts to create a science of international relations see Charles DeBenedetti, 'James T. Shotwell and the Science of International Politics' *Political Science Quarterly*, vol. 89, no. 2, 1974, pp. 379-395. Shotwell was a gradualist who 'was determined to construct an international order of change and stability that melded the interests of various nation-states in institutions approved by statesmen and supervised by a multinational corps of scientists and engineers "in whose hands lie the forces of eternal change."' ibid p. 383. Shotwell himself claimed that 'The day is coming when science will pass from engineering to statecraft.' ibid., p. 395.

[129] Morgenthau, *Politics Among Nations,* pp. 15-22.

[130] Colin Wight, 'Philosophy of Science and International Relations', in Walter Carlsnaes, Thomas Risse and Beth A. Simmons, eds, *The Handbook of International Relations*, Sage, Thousand Oaks, 2002, p. 28.

[131] Molloy, 'Truth, Power, Theory: Hans Morgenthau's Formulation of Realism', p. 5. Molloy states that 'In addition to misunderstanding the nature of man as biological and spiritual in addition to being rational, scientificism 'perverts the natural sciences into an instrument of social salvation for which neither their own nature nor the nature of the social world fit them.' ibid.

[132] See Morgenthau, *Political Theory and International Affairs,* pp 22-24. Yet despite the 'anti-philosophical' stance of modern science, recognised by Morgenthau, it does little to disconnect it from an idea of a natural teleological purpose. For according to Morgenthau 'The Aristotelian conception of truth' was still empirical, 'It was telos, that is to say, purpose, the ultimate aim toward which empirical phenomenon aspired.' Hence the body politic has a natural purpose. ibid., p. 23.

[133] Molloy, 'Truth, Power, Theory: Hans Morgenthau's Formulation of Realism', p. 6. Similarly, Hedley Bull in his attack on the influx of scientific methods into the study of international politics that 'The theory of international relations should undoubtedly attempt to be scientific in the sense of being a coherent, precise

But Wight, in continuing Morgenthau's defence, states that by resorting to a theory built on 'the objective laws of human nature' that there is, according to Morgenthau, 'no need for a science of IR, because IR is governed by laws that are explained by biology, not social science'.[134] Unintentionally, Wight gives the game away. Here, by privileging a biological understanding, lies a scientific reductionist root.[135] Science, via its paradigmatic influence, informed theory construction, even in an instance where a general disdain existed at the increased presence of direct scientific application was held. This is not to misrepresent Morgenthau, who certainly had a differing conception of science, but his work was widely interpreted as being rooted in *a* reductionist science.[136] Moreover, it is difficult to reconcile that such a hermeneutical position of science could *not* have been influenced by the Newtonian worldview. However, for the new breed of science-inclined scholars of IR, Morgenthau and other traditionalists were just not scientific enough. The behaviouralists, as expressed by Gaddis, took the position that:

> A true science of politics would not simply call itself 'scientific,' as Morgenthau had described his theory; rather, it would apply methods of the physical and the natural sciences, to the maximum extent possible, in analysing human and state behaviour. Without the rigor such methods provide, the study of international relations will always be subject to the very utopianism, emotionalism, bias, confusion, and contradiction from which Morgenthau's 'realism' had sought to liberate it."[137]

---

and orderly body of knowledge, and in the sense of being consistent with the philosophical foundations of modern science', Bull, 'International Theory: The Case for a Classical Approach', p. 375.

[134] Wight, 'Philosophy of Science and International Relations', p. 28.

[135] For a more recent and outwardly conscious attempt at a reductionist biological science of IR see Thayer, *Darwin and International Relations*, passim.

[136] Indeed, the German notion of *Wissenschaft*, although of wider scope, does not escape the certainty of science label. Roger Trigg argues, first in respect to theology, but then in respect to the social sciences as having 'been involved in political struggles to retain public recognition as sciences. This is not just a quirk of the English language, though the German 'Wissenschaft' retains a wider scope. It is a sign of a deeply rooted philosophical view in the modern world. Rationality is linked to knowledge, and knowledge to science'. Trigg, *Rationality and Science*, p. 174.

[137] Gaddis, 'International Relations Theory', p. 12. Further Gaddis asserts (very much channelling Newton) that 'The behavioralists proceed from a determinedly inductive, "bottom-up" approach, deferring the construction of theory until they have collected, measured, and compared as much observable evidence as possible, and after that cumulated, replicated, and thus verified the resulting findings. Only then, presumably, can forecasting on any "scientific" basis take place', ibid., p. 13. And a significant issue with the approach, as

Here, an aversion towards the lack of empirical foundation and the ability to test classical realism took root.[138] The fallen man, the world of original sin could be dispensed with; here the 'root [of] realist power politics, including concepts of power and national interest, [lay] securely in the scientifically defensible terrain of objective necessity.'[139] Attaching itself to primitive notion of anarchy that reduced global politics to a world of states that are alike, motivated by the same desires, and differing only in their 'command over material capabilities', neorealism was born.[140]

'A reductionist theory', Waltz declares, 'is a theory about the behaviour of parts. Once the theory that explains the behaviour of the parts is fashioned, no further effort is required'.[141] As a consequence, Waltz considered Morgenthau's theory, with his axiomatic principles, a 'bottom up' interpretation of international politics as 'reductionist'.[142] Instead, he thought his 'top-down' analysis, which focuses on states in an unregulated self-help anarchic structure, as non-reductionist (and systemic). Yet, despite Waltz's accusation that a great many theories of international politics are reductionist,[143] it is 'as reductionist to explain state behaviour solely with reference to anarchical structures as it is to explain

one prominent behaviouralist acknowledged himself, is that 'depending on the variables used, the ways in which they are measured, the spatial-temporal domain covered, and the statistical models that were applied to the data, we obtain appreciably different results', J. David Singer quoted in ibid., p. 23. Singer had an enormous influence of behaviouralist field. It was he who also said that simplifying and, effectively, reducing to a few homogenised units is undertaken so that 'correlative statements' can be produced from the observation and measurement of 'certain forces or stimuli'. What are sought are general patterns of behaviour. Singer, 'The Level-of-Analysis Problem in International Relations', p. 82. In seeking 'reliable *prediction*' Singer wishes the move away from the 'the intuition and artistic tradition of the humanities'. Indeed, the positivism and reductionism is striking in his desire to move away from the 'vertical drift' and other 'significant variable[s]' because of the failure 'to appreciate the value of a stable point of focus'. ibid., p. 78.

138 Steve Smith quoted in Shimko, 'Realism, Neorealism, and American Liberalism', p. 295.

139 Ashley, 'The Poverty of Neorealism', p. 233.. See also Shimko, 'Realism, Neorealism, and American Liberalism', p. 296.

140 Aaron Beers Sampson, 'Tropical Anarchy: Waltz, Wendt, and the Way We Imagine International Politics', *Alternatives*, vol. 27, no. 1, 2002, p. 440. See Waltz, *Theory of International Politics*, pp. 100-1.

141 Waltz, *Theory of International Politics*, p. 60. Briefly, 'Theories of international politics that concentrate causes at the individual or national level are reductionist; theories that conceive of causes operating at the international level as well are systemic'. ibid., p. 18.

142 Shimko, 'Realism, Neorealism, and American Liberalism', p. 293.

143 Waltz, *Theory of International Politics*, pp. 18-19.

international systemic outcomes solely with reference to state preferences'.[144] What occurs is an 'ontological reductionism' whereby states are merely constrained units of analysis as opposed to agents that generate.[145] Furthermore, as one reviewer noted, in his attempt to steer clear of the reductionist label Waltz 'becomes ostensibly a reductionist within the more common meaning of the word: reducing the complex phenomena of world politics to overly simple terms'.[146] For Waltz, this reductionism, which he would not likely admit to, is central to neorealism's viability. This meant that:

> By leaving aside the personality of states, their behaviour, and their interactions, one arrives at a purely positional picture of society. Three propositions follow from this. First, structures may endure while personality, behaviour, and interactions vary widely. Structure is sharply distinguished from actions and interactions. Second a structural definition applies to realms of widely different substance so long as the arrangement of parts is similar … . Third, because this is so, theories developed for one realm may with some modification be applicable to other realms as well.'[147]

It is this reductionism that belies a hidden Newtonian presence. Of course, Waltz is not the 'unreformed positivist' that he is so often accused of being. His scientific method draws on a systemic approach, and does not suggest that classical physics of the Newtonian manner is *directly* applicable.[148] Waltz's systemic approach draws on the Kantian idea of history as a system, which, in turn, drew directly

---

[144] Goddard and Nexon quoted in Sampson, 'Tropical Anarchy: Waltz, Wendt, and the Way We Imagine International Politics', p. 442. Although ultimately Goddard and Nexon argue that Waltz should be recast as a structural functionalist (whereby the system could conceivably be perceived as irreducible and feedback can be interpreted as being endogenous to the system) Stacie E. Goddard and Daniel H. Nexon, 'Paradigm Lost? Reassessing Theory of International Politics', *European Journal of International Relations*, vol. 11, no. 1, 2005, pp. 9-61. See also Wendt, 'The Agent-Structure Problem in International Relations Theory', pp. 341-2.

[145] Alexander Wendt, 'The Agent-Structure Problem in International Relations Theory', *International Organization*, vol. 41, no. 3, 1987, pp. 342.

[146] Robert F. Randle, 'Review Article: *Theory of International Politics* by Kenneth Waltz', *Political Science Quarterly*, vol. 95, no. 1, 1980, p. 137. Although Wendt disputes this 'explanatory' claim Wendt, 'The Agent-Structure Problem', p. 342.

[147] Waltz, *Theory of International Politics*, p. 80. Further, 'Structure defines the arrangement, or the ordering, of the parts of the system.' ibid., p. 81.

[148] Ewan Harrison, 'Waltz, Kant and Systemic Approaches to International Relations', *Review of International Studies*, vol. 28, no. 1, 2002, p. 145.

from the Newtonian vision entrenched with the Enlightenment.[149] This is not to suggest that Waltz was held captive to the ideas of Newton specifically – he wasn't. Nevertheless, the Newtonian paradigm runs deep through his work.

The consequence of this approach is that neorealism presents 'social science as being divorced from broader contextual forces such as interests, values, and cultural predispositions: social theorizing is seen as a purely "scientific" enterprise rather than a social process'.[150] This occurs as a direct result of the manner in which Waltz viewed correct theory construction. Waltz asserts that his use of theory corresponds 'to the definition of the term in the natural sciences and in some of the social sciences, especially economics'.[151] The essence of theory construction, with this in mind, is easily encapsulated. Firstly, for Waltz, laws are established patterns. They affirm a causal relation that has been repeatedly illustrated. Secondly, a theory emerges when a collection of laws can be effectively explained.[152] Brevity follows: 'Theories explain laws'. Moreover, it is from these laws that general prediction is thought possible. Yet, for Waltz, a theory can only predict the repetition and recurrence that may occur within a system, not a change of the system.[153] It is upon this basis that his *Theory of International Politics* is produced. The onset of structural realism, with its scientific-like theory, was a new turn and changed the role science played in IR theory. It avoided the second

---

[149] ibid., pp. 147-8 Harrison notes that although Waltz and Kant merge on the centrality of the need to utilise a systemic method of analysis they rapidly diverge as the 'concrete issues' are brought to bear upon the analysis of their systems. ibid. p. 148.

[150] Shimko, 'Realism, Neorealism, and American Liberalism', p. 296. Waltz considers it imperative for any theory of international relations to separate and delineate form other area of study. He lists 'economic, social and other international domains that one may conceive of.' Waltz, *Theory of International Politics*, p. 79.

[151] Waltz, *Theory of International Politics*, p. 6. To expand: 'The urge to explain is not born of idle curiosity alone. It is produced also by the desire to control, or at least to now if control is possible, rather than to merely predict. Prediction follows from knowledge of the regularity of associations embodied in laws'. ibid. Further, theories are simplifications that envision 'a pattern where none is visible to the naked eye'. ibid. p. 10.

[152] ibid., pp. 1, 5.

[153] ibid., p. 69. Waltz, in respect to neorealism's failure to predict the peaceful end of the Cold War, very much views this as his get out of goal free card. It is also important to stress that 'Linear' theorists should not wear the blame alone when it comes to the desire to build strong predictive models. For example, Alvin Saperstein seeks broad 'regime' predictability. However, despite his many caveats, he is let down by pursuing an idea of science that requires him to be able to answer his own question of whether 'prediction of the unpredictability is believable in an incomplete world'. In doing so he suggests an analogy as to how that might be possible, in the process very much creating his own science of international relations. Saperstein, 'The Prediction of Unpredictability', pp. 139, 147, 150.

debate between traditionalist and behaviouralists. However, Gaddis is quite right in pointing out that Waltz had made 'the same error as the behavioralists … which was to let the method of one's inquiry shape its conclusion';[154] a thought that echoes T.S. Kuhn:

> The man who is successful proves his talents, but he does so by getting a result that the entire scientific community had anticipated someone would someday achieve. His success lies only in the explicit demonstration of a previously implicit agreement between theory and the world. No novelty in nature has been revealed.[155]

What needs to be understood is that science cannot entirely escape its cultural context.[156] Structuralist interpretations, like Waltz's, simply build on an inductive scientific research program, one that accepts the need 'to assume *a priori*' that 'unobservable structures' exist. [157] This is not to dismiss the existence of such structures, otherwise 'reality would be uncharacterizable',[158] but it is an admission that theories are contingent, constructed and selective whenever reductionism occurs. The assumption that they draw from a scientific base of Newtonian certainty should not *a priori* stand. Moreover, the transference of this paradigm via an economic base, which Waltz all too eagerly recognises as *the* theory of social sciences, should not be permitted to occur without comment.[159]

The Neoclassical Economics of International Relations

Morgenthau was a noted critic of the positivist turn in IR theory. However, he deceived himself with his search for axiomatic laws and, more importantly, as Molloy points out, because of his implicit utilisation of *homo economus* for creating

[154] Gaddis, 'International Relations Theory', p. 34.
[155] Kuhn, 'The Function of Measurement', p. 171.
[156] Vasquez, *The Power of Power Politics*, p. 228. This is not to dismiss 'correspondence and coherence theory of truth' as it does acts as a 'final check' ibid.
[157] Gaddis, 'International Relations Theory', p. 14.
[158] ibid., p. 14. With the further complication that 'forecasting would be impossible'. ibid.
[159] For a good introduction to how an economic understanding of international relations has taken root see James A. Caporaso, 'Microeconomics and International Political Economy: The Neoclassical Approach to Institutions' in Ernst-Otto Czempiel and James Rosenau, eds, *Global Changes and Theoretical Challenges: Approaches to World Politics for the 1990s*, Lexington Books, Lexington, 1989, pp. 135-160.

a theory of international politics.[160] This is a central component of the reductionism in his theory-making. Waltz considers himself immune to the label of reductionist but, as has been argued earlier, neorealism's state-centric focus *is* reductionist because of the manner in which it selects its unit of analysis, and then seeks to provide laws based on their interactions, which are, of course, dictated by his conceptualisation of power which reside in the first and second dimensions. Further, although they should, feedback and emergence have no role to play in how those units are constituted. Indeed, his state-based theory, by his own admission, can be pieced together in precisely the same way that a theory of the market can be established without a theory of the firm:[161] all is stripped away leaving an empty model that defies any theory of emergence. Its neoclassical economic foundation (with its inherent atomistic individualism) results in an ontological reductionism of what constitutes the agents within the system (the states) and determines the nature of their behaviour (their properties); that is, their capabilities. This is the economic ontological foundations of a theory that presupposes that actions of states occur via a rational choice lens.[162] For Gunnell, it is simple: rational choice is derived from the 'metatheory of economics'.[163] Here, laid bare, is the self-interest of *homo economus*.[164]

This occurs primarily because of Waltz's conception of theory-building. In making his question-cum-accusation that a number of IR theory scholars do not 'understand anything about what a theory is', he is quick to point to economics as

---

[160] Molloy, 'Truth, Power, Theory: Hans Morgenthau's Formulation of Realism', p. 6. As Molloy points out 'Economics, the most significant of the social sciences in terms of prediction, serves as a model (though not explicitly) for a science of international relations, as passages such as the following demonstrate: 'No nation has the resources to promote all desirable objectives with equal vigour; all nations must therefore allocate their scarce resources as rationally as possible.' ibid.

[161] Waltz, *Theory of International Politics*, pp. 71-2. The ideas, in their infancy can be traced to his *Man, the State and War*, see ch. 7.

[162] And here '[s]cience gives us the means for understanding reality and the rational person will act in accordance with that understanding.' Ostensibly, here quoting J. Margolis, 'the theory of what it is to be rational cannot be prised apart from the theory of science'. Trigg, *Rationality and Science*, p. 174.

[163] Gunnell, 'Realizing Theory', p. 924.

[164] Alexander Wendt, 'The Agent-Structure Problem in International Relations Theory', *International Organization*, vol. 41, no. 3, 1987, pp. 341-2. Wendt, 'The Agent-Structure Problem', pp. 341-2. Rosenau attempts a similar marriage. He considers both the '*rational actor*' and the '*habit-driven actor*' models as unhelpful extremes. Instead he coins the '*habdaptive actor*' model, where individuals are located 'on the continuum between rote behaviour and adaptive learning', Rosenau, *Turbulence in World Politics*, pp. 227-8.

his basis for simplified and sparse theory-building. In his mind, theories must 'omit things. They make bold simplifications. If they don't, they're not theories. It's the same thing in the natural sciences'.[165] Yet, as Wendt recognises, when in the process of assembling theories, economists generally fail to acknowledge ontological and epistemological questions of 'what is there?' and 'how should we study it?'.[166] This is the case because economics largely continues to accept the positivist framework of the nineteenth century.[167] It is this vision of a scientific-economic world that needs to be confronted by IR theorists who wish to incorporate the presuppositions offered by the complexity sciences. The reason for this is because at present, this most 'scientific' of social theories – economics – remains beholden to equilibrium-based approaches that are derived from classical physics.[168] Chicago School economist, Milton Friedman, illustrates the paradigmatic dominance of this view when he unapologetically claimed that, 'In short, positive economics is, or can be, an "objective" science, in precisely the same sense as any of the physical sciences'.[169] Further:

> It has become the orthodoxy in economics to adopt the Cartesian (deductive) mode of analysis and posit equilibrium models premised on utility maximizing, rational agents. The rise to prominence of logical positivism and its variant, logical empiricism, furthered this mode of analysis by including empirical content as the means of making the discipline more scientific. Indeed as T.J.F. Rhia put forth: 'From philosophy and jurisprudence, positivism spread into economics. It has become an accepted view that economic thought, guided by natural laws, can step outside the relationship in which it stands to the problems, the valuations, the behaviours, or even the prejudices of its own time'.[170]

[165] Fred Halliday and Justin Rosenberg, 'Interview with Ken Waltz', *Review of International Studies*, vol. 24, no. 3, 1998, pp. 379-380.
[166] Wendt, *Social Theory of International Politics*, p. 5.
[167] See Mirowski, 'From Mandelbrot to Chaos in Economic Theory', p. 290.
[168] Mathews, et al., 'Why Study the Complexity Sciences', p. 457.
[169] Philip, 'Foundation for Evolutionary Economics?', p. 19.
[170] ibid., pp. 19-20. As discussed in Chapter One, this takes into consideration the subsuming of Cartesian thought by the Newtonian paradigm.

This is the economic ontology that continues to frame an understanding of the international in a cloak of scientific certainty. It is this cloak that has defined the repository of ideas that reflects the study of international relations that is in need of reformulation.[171] An economic ontology commits to what R. G. Collingwood called '*absolute presuppositions*'.[172] From this a fundamental view of the 'contents and confines of the economic realm' are established,[173] and most notable interpretations of Scottish philosopher and political economist Adam Smith's work giving political economy the '*shape*' of an imaginary machine.[174] As will be seen below, ideas of classical economics flowed into the study of international relations. This included ideas like a political equilibrium, which, in its more extreme forms, was thought to be measurable and quantifiable to terms of 'constant dollar expenditure' or 'absolute level of armaments'.[175] It also ranged to more subtle understandings of the international system, whereby agents were pushed, as if by some invisible hand, to a point of balance.[176] The imagined idea that rational, axiomatic maximisers would always drive to a point of equilibrium, pushed or encouraged by a fear of punishment,[177] was, inescapably, a product of the Newtonian worldview. IR theorists continue to be very much drawn and inspired by micro-economic theory. Its influence has, for some, only grown more far-reaching, with the continued emphasis towards research that is guided by

[171] It is worth noting that 'The picture of international relations provided by the realist paradigm has not been displaced, nor for that matter has it been seriously challenged. Klaus Korr and James Rosenau in response to the 'behavioural revolt' not being a paradigm shift provide evidence that the picture has not changed. They state that scholars engaged in the debate do not challenge each other about the way they identify international phenomena.' Vasquez, *The Power of Power Politics*, p. 41.
[172] Collingwood quoted in Uskali Mäki, 'Economic Ontology: Why? What? How?', in Uskali Mäki, ed., *The Economic World View: Studies in the Ontology of Economics*, Cambridge University Press, Cambridge, 2001, p. 5. See also Newman, 'Metaphysics and Absolute Presuppositions', pp. 290-92.
[173] ibid. p. 4.
[174] Andrew S. Skinner, 'The Shaping of Political Economy in the Enlightenment', *Scottish Journal of Political Economy*, vol. 37, no. 2, 1990, p. 157. Moreover, others were to find 'a new classical orthodoxy' in Smith, which in time became increasingly simplified. ibid. pp. 160, 162.
[175] Deutsch and Singer, 'Multipolar Power Systems', pp. 391-2. Here they draw on the work of Morton Kaplan.
[176] Ernst B. Haas, 'The Balance of Power: Prescription, Concept, or Propaganda', *World Politics*, vol 15, no. 4, 1953, p. 455.
[177] Effectively, the punishment occurs because of 'competitive pressure' or 'survival of the fittest', with obvious Smithian, Ricardian and Darwinian overtones. See Deutsch and Singer, 'Multipolar Power Systems', p. 402.

rational choice theory;[178] a theory that dominates IR research in the United States.[179] Exclusively in the realm of economics, rational choice theory

> … can predict with considerable accuracy how an interest rate rise will affect unemployment, or growth. It does this without having a second's concern with the internal workings of the actors involved. It is a black-box model, focused on the correlation between inputs and outputs.[180]

Mainstream IR theorising needs to unmask the scientificism of economics so as to allow a level of release from the certainty enshrined in this pseudo-scientific approach. Here it can be said that it is time to start 'looking at the ontological windows instead of merely *looking through* them'.[181]

Economics is the most telling example of the mathematisation of a field under the aura of a 'scientific approach'. While, on the one hand, it has been elevated because of its perceived scientific base, on the other hand, it has attracted the criticism of stripping away social elements in its attempt to replicate the hard sciences, especially physics.[182] Economics, in its traditional garb, celebrates the atomisation of society, in which the rational actions of individuals allow a linear and additive conception to contribute to the construction of a whole. From an economic ontological perspective, wholes are understandable as a composite of their parts, and, importantly for IR theory, this represents the reduction up to aggregated units that are portrayed to act similarly to rational individuals.[183] From this the strong and generalised assumptions that support notions of 'general equilibria' are seen to only hold when 'society as a whole' is thought to behave 'as

---

[178] Cederman, 'Modeling the Size of Wars, p. 145. On the correlation between economic, rational choice theory and international relations see also Brown *Understanding International Relations*, p. 30. Interestingly, rational choice theory is also known as 'positive theory'. See Russell Hardin, 'The Normative Core of Rational Choice Theory' in Uskali Mäki, ed., *The Economic World View: Studies in the Ontology of Economics*, Cambridge University Press, Cambridge, 2001, p. 57. Finally, it should be recognised that there are some difficulties reconciling rational choice theory and Waltz's *Theory of International Politics*.

[179] Steve Smith, 'Singing Our World into Existence: International Relations Theory and September 11', *International Studies Quarterly*, vol. 48, no. 3, 2004, p. 502.

[180] ibid.

[181] Mäki, 'Economic Ontology', p. 6.

[182] For example, see Giddens, *Sociology: A Brief but Critical Introduction*, p. 13.

[183] For example, see Harrison, 'Thinking About the World We Make', pp. 6-7.

if it were a single individual'.[184] The most compelling conceptualisation of this idea was captured by Smith's 'invisible hand'; a great invisible machine,[185] guiding society, unchecked and without the specific aim, towards a public good. In Smith's words, and, indeed, the only time the invisible hand is mentioned in *The Wealth of Nations,*[186] he contends that:

> As every individual, therefore, endeavours as much he can both to employ his capital in the support of domestick industry, and so to direct that industry that its produce may be of the greatest value; every individual necessarily labours to render the annual revenue of the society as great as he can. He generally, indeed, neither intends to promote the publick interest, nor knows how much he is promoting it. By preferring the support of domestick to that of foreign industry, he intends only his own security; and by directing that industry in such a manner as its produce may be of the greatest value, he intends only his own gain, and he is in this, as in many other cases, led by an invisible hand to promote an end which was no part of his intention. Nor is it always the worse for the society that it was not part of it. By pursuing his own interest he frequently promotes that of the society more effectually than when he really intends to promote it. I have never known much good done by those who affected to trade for the publick good. It is an affectation, indeed, not very common among merchants, and very few words need be employed in dissuading them from it.[187]

It is from this passage that the idea of a natural equilibrium, as a fundamental principle within mainstream theories of economics, gained currency. To describe it, the invisible hand can be said to be a system that is self-regulated by self-interest, with the competitive processes of the market generating 'actual' market prices around a supposed natural price for that particular market. Via many iterations, utility and self-interest help establish a general market equilibrium from

[184] Geoffrey M. Hodgson, 'Economics and the Return to Mecca: the Recognition of Novelty and Emergence', *Structural Change and Economic Dynamics*, vol. 8, no. 4, 1997, p. 403.
[185] Drawing on Hume, imagination is pivotal as a starting point for any scientific examination as it 'supplied the common-sense belief in the real'. Smith accepts this, but in incorporating it he characterises 'systems' as 'imaginary machines', Shelia C. Dow, 'Interpretation: The Case of David Hume', pp. 407-8, 415.
[186] The phrase first appears in his *Theory of Moral Sentiments* published seventeen year earlier. See Adam Smith, *The Theory of Moral Sentiments*, D. D. Raphael and A. L. Macfie, eds, Clarendon Press, Oxford, 1976 [1759], [IV.i.10], p. 184. He also refers to what appear to be natural desires for symmetry and order. ibid. [IV.i.1-i.5], pp. 179-80.
[187] Adam Smith, *An Inquiry into the Nature and Causes of the Wealth of Nations*, vol. 1, R. H. Campbell and A. S. Skinner, eds, Clarendon Press, Oxford, 1976 [1776], [IV.ii.9], p. 456.

which the imagined 'common good' is achieved.[188] The resultant neoclassical microeconomic focus on general equilibrium theory[189] was built upon Smith's ideas, recasting him as a rational choice theorist,[190] irrespective of his other important philosophical works.[191] That aside, what arose in a short time in the mathematically-based theories of neoclassical economists was the idealisation of a deterministic understanding similar to those that have been widely used in the realm of physics.[192] Such a conception now dominates an enormous amount of thought, extending well beyond economics.[193] In turn, this has created a predominately singular idea as to what the study of economics represents, the inherent problem being that it is taken to reflect a notion of reality is. Unfortunately, it is a reality that is constructed on absolute presuppositions that are coloured by Newtonian science.[194] Indeed, as Toulmin has argued, 'we find close parallels between their ideas about *equilibrium* in economics and Newtonian ideas about the dynamics of the planetary system'.[195] Admittedly, Smith's idea of rationality and rational agents is significantly more complex and substantial than

[188] Witt, 'Self-Organization and Economics', p. 490.

[189] For example, see Frank Ackerman, 'Still dead after all these years: interpreting the failure of general equilibrium theory', *Journal of Economic Methodology*, vol. 9, no. 2, 2002, pp. 119-39; David Colander, 'The Death of Neoclassical Economics', *Journal of the History of Economic Thought*, vol. 22, no. 2, 2000, pp. 127-43; For an interesting counterpoint, see Robert B. Ekelund Jr. and Robert F. Hébert, 'Retrospective: The Origins of Neoclassical Microeconomics', *Journal of Economic Perspectives*, vol. 16, no. 3, 2002, pp. 197-215.

[190] It should be pointed out that 'for classical economists, rationality was a much more complex affair than the mere avoidance of being fooled. Smith, in particular, had grand and complex views about what is rational for men to do.' Maurice Lagueux, 'The Forgotten Role of the Rationality Principle in Economics', *Journal of Economic Methodology*, vol. 11, no. 1, 2004, p. 34.

[191] Again it is important to stress the depth that runs beneath many of these homogenised concepts: 'Time and again, scholars invoke the theories of writers like Hobbes, Locke and Smith as the roots of the conception of 'economic man' or 'the rational individual', the utility-maximizing chooser of contemporary liberalism and rational choice theory. But scholars who take a close look at their writings find, in every case, a much richer psychology than that expressed in the mechanical axioms of contemporary economic rationality.' Ruth W. Grant, 'The Ethics of Incentives: Historical Origins and Contemporary Understandings', *Economics and Philosophy*, vol. 18 no. 1, 2002, p. 125. Reductionism, it would seem, is a self-perpetuating machine.

[192] Mirowski, 'From Mandelbrot to Chaos in Economic Theory', p. 290.

[193] For example, in the area of sociology, 'one of the few general theories applied (particularly by Smith and Hume) is the rational choice model, 'the economic model of man' or 'utilitarian theory'", Karl-Dieter Opp quoted in Milan Zafirovski, 'The Rational Choice Generalization of Neoclassical Economics Reconsidered: Any Theoretical Legitimation for Economic Imperialism?', *Sociological Theory*, vol. 18, no. 3, 2000, p. 452.

[194] Indeed, Collingwood recognises that a particular metaphysical position reflects, to some extent, views held with the society, thus informing the presuppositions. See Newman, 'Metaphysics and Absolute Presuppositions', p. 283.

[195] Toulmin, 'The Idol of Stability', p. 338. It is also important to remember that natural and human systems do differ, making analogies between, say, chemical reactions and the economy difficult. Human agency is driven by intelligence and imagination – not something generally found as an explanatory factor for the average chemical reaction. Witt, 'Self-Organization and Economics', p. 497.

is often portrayed in many contemporary discourses.[196] However, this does not allow economists, who have built upon the principles of rationality which push systems to a natural equilibrium, to escape the accusation that:

> Of all human scientists, the ones most confident of the rigor of their methods and superiority of their results are the economists who develop abstract, universal mathematical systems. The formality of their arguments carries an air of theoretical rigor; the generality of their concepts gives them the appearance of practical universality; and, as a result, the ideas of 'neo-classical equilibrium analysis' have a special prestige among academic economists.[197]

Smith, whose work remains significant for mainstream economists, felt that the relation of price to supply and demand was inextricably linked to negative feedback, from which general economic stability would emerge. Consequently, it was, and in some circumstance still is, assumed that any movement away from equilibrium will meet resistance with these 'laws', with the equilibrium, or natural, prices being restored.[198] It is an idea that has cascaded through the social sciences: deviation from the natural order would result in punishment. This sentiment is echoed in a Kuhnian perspective, which acknowledges that:

> There is a strongly individualistic emphasis in the rationalist account: progress from unconstrained individual decisions, just as is claimed by the theories of our Treasury economist; and social interference introduces undesirable distortions into the system.[199]

Similarly, Mandelbrot dismissed 'Bourbakist formalism' of economic theory that focuses on axiomisation, seeing the continued reduction to axioms being a self-

---

[196] Lagueux, 'The Forgotten Role of the Rationality Principle in Economics', p. 34. Indeed, upon closer examination, Smith certainly had an awareness that human agents could subvert this equilibrium through the imposition of such artificial constraints as monopolies and corporation laws. See Adam Smith, *Lectures on Jurisprudence*, R.L. Meek, D.D. Raphael and L.G. Stein, eds, Oxford University Press, Oxford, 1978, [306-7], p. 529.

[197] Toulmin, 'The Idol of Stability', p. 337.

[198] John L Casti, 'Complexity - An Introduction', http://www.giacs.org/files/exystence_files/casti.pdf , pp. 8-9, (accessed 17/08/2004).

[199] Barnes, 'Thomas Kuhn', p. 86. Barnes also highlights the linear scientific gradualism present: 'Finally, the rationalist account reflects the cherished liberal idea of gradual evolutionary change: scientific progress stands in this respect as a gratifying analogue of social progress' ibid.

fulfilling process (arguably, a form of self-organisation in itself) that was essentially driven by a desire to please the teacher.[200] However, it is the movement away from equilibria, via positive feedback, that has captured the attention of those who study complex systems, suggesting that instability is a part of the economic system.[201] From it, the idea of 'the all-knowing, rational *homo economicus* is increasingly under siege for its assumption of ubiquitous information and insensitivity to local context'.[202] These differing conceptual approaches run in the face of rational choice theories that suggest an optimal fitness of agents because 'the space of possibilities is too vast' and agents 'have no practical way of finding the optimum'[203]. No matter how sophisticatedly rational choice theorists attempt to frame choice,[204] it difficult to ignore that:

> Optimization models … ignore both the possibility of radical transformations – that is, transformations that change the definitions of a problem and thus the kind of solution sought – and the initial constraints that may eventually enforce a system into a disastrous way of functioning. Like doctrines such as Adam Smith's invisible hand or other definitions of progress in terms of maximisation or minimization criteria, this gives a reassuring reinterpretation of nature as an all-powerful and rational calculator, and of a coherent history characterized by global progress. To restore both inertia and the possibility of unanticipated events – that is, to restore the open character of history we must accept its fundamental uncertainty.[205]

Inherent in any form of optimisation is reductionism, and, in modern economics, it is still reflective of the Newtonian worldview, given that the 'relations among human beings … invariably reduced to relations of exchange equivalents, as if

---

[200] Mirowski, 'From Mandelbrot to Chaos in Economic Theory', p. 292. See also in relation to the 'Bourbakist programme' T.A. Boylan and P.F. O'Gorman, 'Axiomatization and Formalism in Economics', *Journal of Economic Surveys*, vol. 21, no. 3, 2007, pp. 426-46. It is also important to realise that Nicholas Bourbaki (from which Bourbakist is taken) was not a single person but a collective of early twentieth century mathematicians who anonymously sought to reformulate the 'foundations of mathematics'. David L. Hull, 'What's Wrong with Invisible-Hand Explanations?', *Philosophy of Science: Supplement. Proceedings of the 1996 Biennial Meetings of the Philosophy of Science Association*, vol. 64, 1997, p. S124.
[201] Casti, 'Complexity - An Introduction', pp. 8-9.
[202] Manson, 'Simplifying Complexity', p. 409.
[203] Holland quoted in Bronk, *Progress and the Invisible Hand*, p. 199.
[204] See, for example, See Hardin, 'The Normative Core of Rational Choice Theory'.
[205] Prigogine and Stengers, *Order Out of Chaos*, p. 207

these were the only ones worthy of economic interest'.[206] As Toulmin succinctly puts it: 'we shall find that the human sciences – not least theoretical economics – based their research programs, not on realistic ideas about the *actual* methods of physics, but on their vision of a physics that never was'.[207] However, a new emphasis is emerging that suggests that society can only be understood as whole, with the 'the legal, social, material, and spiritual values … the driving force of economic systems'.[208] This point is important because neoclassical economics:

> rests on general competitive equilibrium theory. This beautiful theory demands infinitely rational economic agents and what are called "complete markets". Such markets allow exchange of all possible dated contingent goods, an example would be to deliver apples tomorrow if it rains in Nebraska today. In the absences of infinite rationality and complete markets, we see failure of beautiful theorems guaranteeing an equilibrium ...[209]

The acceptance within rationalist-based theories of IR, especially neorealism and neoliberalism, of such equilibrium-driving and reductionist-based models is considerable. Even considering admissions that there has been a movement away from the basic 'billiard ball' or 'black box' type models in IR; the primary aim, by accepting the neoclassical economic base, being to provide a certain level of prediction.[210] The economic model, it is argued, enhances the general understanding of international relations, represents better theory, and, via its own

[206] Stefano Zamagni, 'Economic Reductionism as a Hindrance to the Analysis of Structural Change: Scattered Notes', *Structural Change and Economic Dynamics*, vol. 11, no. 1-2, 2000, p. 198.

[207] Toulmin, 'The Idol of Stability', p. 329.

[208] Philip, 'Foundation for Evolutionary Economics?', p. 30. And from that the author states the '"objects" of economic inquiry cannot be atomistic man', ibid.

[209] Kauffman, *Origins of Order*, pp. 398-99. Damningly, neoclassical economists 'naturally tended to think of models in which things settle down to a unique position *independently of initial conditions* [emphasis added]. Technically speaking, we theorists hoped not to introduce *hysteresis* phenomena into our model, as the Bible does when it says, "We pass this way only once" and, in so saying, takes the subject out of the realm of science and into the realm of genuine history. Paul Samuelson quoted in Mirowski, 'From Mandelbrot to Chaos in Economic Theory', p. 291. In addition, '…particularly in the context of game theory and cybernetics the idea had developed in the 1940s that it should be possible to make mathematical predictions even about complex human situations. And for example starting in the early 1950s government control of economies based on predictions from linear model became common. By the early 1970s, however, such approaches were generally seen as unsuccessful, but it was usually assumed that the reason was not fundamental, but was just that there were too many disparate elements to handle in practice.' Wolfram, *New Kind of Science*, p. 1132.

[210] Keohane and Nye, *Power and Interdependence*, pp. 196-7. See also Singer, 'The Level-of-Analysis Problem in International Relations', pp. 81-2.

ontology, captures an essence of reality. To this end, Kuhn had much to say about theory progression:

> Compared with the notion of progress most prevalent among both philosophers of science and laymen, however, this position lacks an essential element. A scientific theory is usually felt to be better than its predecessors not only in the sense that it is a better instrument for discovering and solving puzzles but also because it is somehow a better representation of what nature is really like. One often hears that successive theories grow ever closer to, or approximate more and more closely to, the truth. Apparently generalisations like that refer not to the puzzle-solutions and the concrete predictions derived from a theory but rather to its ontology, to the match, that is, between the entities with which the theory populates nature and what is 'really there.'[211]

Consider, then, that Keohane and Nye unashamedly erected their neoliberal institutionalism on this neoclassical economic base.[212] Indeed, the general neoliberal position accepts from this that 'the two basic assumptions of international anarchy and the rational egoism of states'.[213] There lies here a commitment to ordering, at the meta-theoretical level, how the world is imagined via the dominant paradigm. The neorealism of Waltz, as has been shown, makes a similar commitment, yet it is not demonstrated 'why economic theory and international theory are homologous, other than by making vague comparisons related to structure'.[214] He is committing the sin, in the Kuhnian sense, of explaining what is 'really there', and what fits into his ontological worldview. Of his many declarations in his *Theory of International Politics,* take Waltz's call that

---

[211] Kuhn, *The Structure of Scientific Revolutions*, 2nd ed., p. 206.

[212] Keohane and Nye, *Power and Interdependence*, pp. 33-40. 'Indeed, struggles over the governance of economic issues are responsible for much of the increased attention to interdependence. The contemporary Western science of international economics, however, does not have a theory of international regime change. Neoclassical economic analysis was developed not as a faithful description of reality, but as a simplified explanation that would also suggest policies for increasing economic efficiency and welfare. Quite deliberately, economic theorist have abstracted away from politics in order to achieve more precise and elegant economic explanations. Thus we cannot blame economist for not providing a model of regime change from conventional economic theory, because their questions are different from political scientists'. ibid., p. 33. Waltz is also quick to point out that 'Theories do construct *a* reality, but no one can ever say that it is *the* reality'. Waltz, *Theory of International Politics*, p. 9.

[213] Brown, *Understanding International Relations*, p. 46.

[214] Molloy, 'Realism: A Problematic Paradigm', p. 73. 'In fact, [Waltz] berates 'economists' and 'economically minded political scientists', raising the question of why then is his use legitimate? ibid.

'[i]nternational-political systems, like economic markets, are formed by a coaction of self regarding units'.[215] He also declares, with a nod to Adam Smith, that '[i]nternational political systems, like economic markets, are individualist in origin, spontaneously generated, and unintended'. [216] Here, therefore, lies an expression of one of the most dominant ideas in relation to IR theory: that of the natural equilibrium.

In this respect, balance of power theory is based on assumptions derived from negative feedback, akin to the invisible hand of Adam Smith.[217] Central notions like balance of power, or anarchic descriptions of international politics, are to be criticised for relying upon an equilibrium-based understanding of the international system, which fails to allow sufficiently for the fluidity and far-from-equilibrium processes that take place as a result of constant fluctuations.[218] John Ruggie observed that there was a direct lineage between the Newtonian-influenced balance-of-power adherents of the seventeenth and eighteenth century, who venerated 'the self regulating equilibrium as a venerable institution of European society', to the work of both Waltz and Immanuel Wallerstein. Indeed, in calling them the 'physicalists', he connects them to an idea of structure that influential chaos and complexity thinker Ilya Prigogine considered to privilege being over becoming.[219] This is tied to the old meta-theoretical dilemma of how

[215] Waltz, *Theory of International Politics*, p. 91. 'And both systems [the economic and the international] are formed on a principle of *self-help* that applies to the units.' ibid. Emphasis added. It is worth highlighting that 'Although Waltz's preferred analogy is to micro-economics, the selection metaphor also suggest an analogy to socio-biology, which aspires quite explicitly to a material analysis of social life'. Wendt, *Social Theory of International Politics*, p. 100. This, of course, only reinforces his commitment to traditional scientific theorising.
[216] Waltz, *Theory of International Politics*, p. 91.
[217] Jervis, *System Effects*, p. 132.
[218] Modelski, 'Evolutionary Paradigm for Global Politics', p. 332. Moreover, in terms of thinking of embracing any level of holism, 'neorealism is no more holistic than the micro-economic theory upon which Waltz draws by analogy to develop it.' Alexander Wendt, 'Bridging the Theory/Meta-Theory Gap in International Relations', *Review of International Studies*, vol. 17, no. 4, 1991, p. 388.
[219] John Gerard Ruggie, 'International Structure and International Transformation: Space, Time, and Method' in Ernst-Otto Czempiel and James Rosenau, eds, *Global Changes and Theoretical Challenges: Approaches to World Politics for the 1990s*, Lexington Books, Lexington, 1989, p. 28. Further, on Nobel Prize winning Ilya Prigogine view on the ontological question of being over becoming, see Prigogine and Stengers, *Order Out of Chaos*, esp. p. 310. Also see his more recent text, Prigogine, *The End of Certainty*

time can be understood differently,[220] a debate that does not lie too far from conjecture invited by Heraclites's notion 'that you cannot you step in the same river twice'.[221] Of course, it is this physicalist structure of the international system that Ruggie identifies as one that must be moved beyond.[222] However, before this can be achieved, it is imperative to revisit the idea that power balances.

Balancing International Politics

As the discipline of International Relations sought new directions in the post-Second World War period, the notion of the balance of power became entrenched in the IR literature. It became an idea bound in common-sense.[223] Arnold Wolfers accepted it, in the most general of forms, to mean 'the equilibrium of an evenly balanced scale'.[224] Bull simply accepted the analogy of the balance of power as a given.[225] Against this tide, C. Wright Mills vented his frustration at the fact that the concept emerged as a common-sense idea of a natural balance. Its pedigree in the domestic setting was such, in Mills's opinion, that the majority of Americans

---

[220] Here, Newtonian-like thought can be separated from more dynamic-inspired understandings of the world. Erwin N. Hiebert, 'Book Review: Prigogine Writes on Time Irreversible and Reversible: *From Being to Becoming: Time and Complexity in the Physical Sciences* by Ilya Prigogine', *Physics Today*, vol. 79, no. 1, 1982, pp. 69-70. Indeed, 'being" represents the restricted geometric concept of time that applies to the trajectories of classical dynamics … By contrast "becoming" represents the dynamic, evolutionary, time concept current in statistical physics and chemistry and biology' ibid., p. 69.

[221] Waldrop, *Complexity*, p. 88.

[222] Ruggie, 'International Structure and International Transformation', pp. 27-29.

[223] In a non-international relations framework, Mills takes issue with balance of power theory. Its perceived usefulness over shortening timeframes particularly caught his ire. In his view, a shortcoming of the social sciences, presumably of a positivist and behaviouralist bent, as they were emerging in the period following the Second World War, was the search for a method, and more often than not a model, that adequately explains the multiplicity of events in a manner that neatly summed up modern society. C. Wright Mills, *The Power Elite*, Oxford University Press, Oxford, 1956, p. 245.

[224] Arnold Wolfers, *Discord and Collaboration: Essays on International Politics*, The John Hopkins Press, Baltimore, 1962, p. 118. Wolfers was also quick to point out that the United States had very much taken to it role as a balancer despites the fact that it was 'a country so little accustomed to or inclined towards power calculations in foreign affairs to be able to switch sides from former friends to former enemies if such a move were necessary for the restoration of the world balance of power'. ibid. p. 127. C. Wright Mills disdainfully noted a similar analogy and the manner in which it related directly to society: 'Balance of power' implies equality of power, and equality of power seems wholly fair and even honourable, but in fact what is one man's honourable balance is often another's unfair balance. Ascendant groups of course tend readily to proclaim a just balance of power and a true harmony of interest, for they prefer their domination to be uninterrupted and peaceful. So large businessmen condemn small labor leaders as 'disturbers of the peace' and upsetters of the universal interest inherent in business-labor co-operation. Mills, *The Power Elite*, p. 246.

[225] Bull, *The Anarchical Society*, ch. 5. Although Bull qualifies between objective and subjective balancing. ibid. p. 99. Although, conceivably, it may have been better framed as perception and misperception. For example see Robert Jervis, *Perception and Misperception in International Politics*, Princeton University Press, Princeton, 1976.

considered government, as if it was some 'sort of automatic machine, regulated by the balancing of competing interest'.[226] Mills was, however, well aware that the idea predated the twentieth century.[227] The Treaty of Utrecht enshrined the notion as a guiding principle for states for the first time in 1713.[228] Herbert Butterfield stressed that the idea did not impose itself on an understanding of relations between states until the eighteenth century, thereby denying any links to the ancients, either as original architects of the idea or via a modern reinterpretation of their writings.[229] Hume thought differently, in that an idea of a balance of power had always existed, perhaps unstated, in politics, yet as a construction of the mind it was of no real use.[230] His thoughts centred on the idea that:

> the maxim of preserving the balance of power is founded so much on common sense and obvious reasoning, that it is impossible it could altogether have escaped antiquity, where we find, in other particulars, so many marks of deep penetration and discernment. If it was not so generally known and acknowledged as at present, it had, at least, an influence on all the wiser and more experienced princes and politicians. And indeed, even at present, however generally known and acknowledged among speculative reasoners, it has not, in

---

226 Mills, *The Power Elite*, p. 242.
227 ibid. Mills continues: 'The ideal of the automatic balance reached its most compelling elaboration in eighteenth-century economic terms: the market is sovereign and in the magic economy of the small entrepreneur there is no authoritarian center. And in the political sphere as well: the division, the equilibrium, of powers prevails, and hence there is no chance of despotism.' ibid.
228 Denys P. Myers, 'The Bases of International Relations', The American Journal of International Law, vol. 31, no. 3, 1937, p. 438; Richard Little, *The Balance of Power in International Relations*, Cambridge University Press, Cambridge, 2007, pp. 67, 157; Michael Sheehan, *The Balance of Power: History and Theory*, Routledge, London and New York, 1996, p. 104. John Gerald Ruggie, Territoriality and Beyond: Problematizing Modernity in International Relations', *International Organisation,* vol. 47, no. 1, 1993, p. 146. Richard Cobden noted it first utterance in Britain (and of Britain) in 1701 in a speech delivered by William III. Richard Cobden, *Political Writings*, W. Ridgeway, London, 1878, p. 110.
229 Herbert Butterfield, 'The Balance of Power' in Herbert Butterfield and Martin Wight, eds, *Diplomatic Investigations: Essays in the Theory of International Politics*, Allen and Unwin, London, 1966, pp. 133, 143; Butterfield, *International Conflict in the Twentieth Century*, pp. 51-2. See also for an elaboration: Michael Sheehan, *The Balance of Power: History and Theory*, 24-36. Morgenthau's position is reconcilable with both Butterfield and Hume when he states that 'While the balance of power as a natural and inevitable power is as old as political history itself, systemic theoretic reflections, starting in the sixteenth century and reaching their culmination in the eighteenth and nineteenth century, have conceived the balance of power generally as a protective device of an alliance of nations, anxious for their independence, against another nation's designs for world domination, then called universal monarchy.' Morgenthau, *Politics Among Nations*, p. 180. See, in respect to this, Sheehan, *The Balance of Power*, pp. 36, 41.
230 Patomäki and Wight, 'After Postpositivism?', p. 220.

> practice, an authority much more extensive among those who govern the world.[231]

For Hume, the balance of power was effectively a mental exercise that was indicative of the 'connexion in our thought'.[232] Richard Cobden took this further, declaring 'the balance of power is a chimera! It is not a fallacy, a mistake, an imposture – it is an undescribed, indescribable, incomprehensible nothing'.[233] Yet, it permitted the establishment of an ordering mechanism that assisted understanding, much in the same way Krasner's tacit acknowledgment of the different usage of sovereignty offered different visions of statehood. Indeed, it is not difficult to suggest that, in the Humean sense, creating a balance in the mind's eye was driven by the passions seeking to rationalise and layer a sense of knowable and desired order over the world.[234]

This shifts the idea of balance of power to a position of contingency, context and contestability. This is clearly apparent in respect to Morgenthau's idea of balance of power, which was far from concrete, and most certainly lacked consistency with slippage between differing usages occurring throughout his seminal *Politics Among Nations*.[235] However, despite this definitional slipperiness, his conception draws from Newtonian-inspired ideas of natural balance. This is emphasised by his interpretation of the evolution of the concept of a natural equilibrium as a guiding mechanism for understanding the affairs and relations between states.[236] Placing its zenith in the eighteenth century, he quotes the enlightened absolutist

---

[231] David Hume, 'On the Balance of Power', *Essays, Moral, Political, and Literary*, Eugene F. Miller, ed., Liberty Classic, Indianapolis, 1985 [1777], Part II, Essay VII, pp. 337-8. See also Patomäki and Wight, 'After Postpositivism?', p. 220. Waltz also notes Hume's essay on power balancing but with little insight. Waltz, *Theory of International Politics*, p. 119.

[232] Hume quoted in Patomäki and Wight, 'After Postpositivism?', p. 220.

[233] Cobden, *Political Writings*, p. 111. Further, Cobden noted that the idea that a nation can 'hold the balance' is a phrase that pleases the 'public ear', ibid., pp. 110-11.

[234] Hume touches on this, presenting a notion order that arises in an inversion of modern balance of power theory. Indeed, coupled with staleness that occurs within ageing regimes, the desire to pursue or maintain the balance results in the position where 'ambition blindly labours for the destruction of the conqueror, of his family, and of every thing near and dear to him.' Hume, 'On the Balance of Power', p. 341.

[235] Brown, *Understanding International Relations*, p. 98.

[236] Morgenthau, *Politics Among Nations*, p. 183. Indeed, 'Newton's model of the universe was rapidly adopted as the new consensus because it offered an end to a long period of intellectual uncertainty in Europe.' Sheehan, *The Balance of Power: History and Theory*, p. 47.

Frederick the Great.[237] However, he draws on the Prussian king without acknowledging the depth of the connection between the advance of Enlightenment science, and how the politics of the period were conceptualised.[238] Indeed, Frederick the Great and Voltaire corresponded frequently on a diverse range of matters, culminating in Voltaire joining his court for a three-year period (similarly, at the court of Catherine the Great, the mathematician Leonhard Euler was of considerable influence).[239] Here, in the tract that Morgenthau uses, Frederick the Great details his image of international, or, rather, European, politics:

> It is easy to see that the political body of Europe finds itself in a violent condition: it has, so to speak lost its equilibrium and is in a state where it cannot remain for long without risking much. It is with it as it is with the human body which subsists only through the mixture of equal quantities of acids and alkalies; when either of the two substances predominates, the body resents it and its health is considerably affected. And when this substance increases still more, it can cause the total destruction of the machine. Thus, when the policy and the prudence of the princes of Europe lose sight of the maintenance of a just balance among the dominant powers, the constitution of the whole body politic resents it: violence is found on one side, weakness on the other; in one, the desire to invade everything, in the other the impossibility to prevent it; the most powerful imposes laws, the weakest is compelled to subscribe to them; finally, everything concurs in augmenting the disorder and confusion; the most powerful, like an impetuous torrent, overflows its banks, carries everything with it, and exposes this unfortunate body to the most disastrous revolutions.[240]

---

237 Morgenthau, *Politics Among Nations*, p. 183.

238 See, for example, James T. McHugh 'Last of the Enlightened Despots: A Comparison of President Mikhail Gorbachev and Emperor Joseph II' *The Social Science Journal*, vol. 32, no. 1, 1995, pp. 70-1. On the spread of Enlightenment ideals of politics to the so-called enlightened despots the '*Politische Journal* represented an attempt to provide German readers with political news in a rational and systematic form'. See Jeremy D. Popkin, 'Political Communication in the German Enlightenment: Gottlob Benedikt von Schirach's Politische Journal' *Eighteenth-Century Life*, vol. 20, no. 1, 1996, p. 28 and passim.

239 See Ahnert, 'Newtonianism in Early Enlightenment Germany, p. 482. Voltaire (along with Maupertius) was chiefly responsible for 'disseminating Newtonian thought', Ronald S. Calinger, 'Frederick the Great and the Berlin Academy of Science (1740-1766)', *Annals of Science*, vol. 24, no. 3, p. 248. Further, Frederick himself though science to 'the servant of the state'. ibid. p. 239.

240 Morgenthau, *Politics Among Nations*, p. 183. The translation, from the French, is Morgenthau's own. Indeed, Frederick looked to France as the guiding light of the Enlightenment. Calinger, 'Frederick the Great and the Berlin Academy of Science', p. 240.

Here, the order is conceived of as natural, with the body as a machine needing to function as a deterministic whole. Morgenthau affirms this with his comment that the concept of the balance of power was a 'metaphor taken from the field of mechanics', and that it was a vision of 'the whole universe as a gigantic mechanism, a machine or a clockwork, created and kept in motion by the divine watchmaker'.[241] This mental picture of automatic 'behavioural regularity' is the inspiration of its perception as a 'key law',[242] which so obviously draws on the Newtonian paradigm. The revelations contained within 'this mechanistic philosophy'[243] of stability and order is a prominent example of how the dominant scientific paradigm of the Scientific Revolution and the European Enlightenment leeched into the study of social systems. Morgenthau thereby captured the accepted scientificism of equilibrium-based mechanics, recording that:

> The concept of 'equilibrium' as a synonym for balance' is commonly employed in many sciences – physics, biology, economics, sociology, and political science. It signifies stability within a system composed of a number of autonomous forces. Whenever the equilibrium is disturbed either by an outside force or by change in one or the other elements composing the system, the system shows a tendency to re-establish either the original or a new equilibrium.[244]

[241] Morgenthau, *Politics Among Nations*, p. 197.
[242] Vasquez, *The Power of Power Politics*, p. 191. Although Vasquez notes that Morgenthau did not always adhere to this principle. ibid.
[243] Morgenthau, *Politics Among Nations*, p. 197. Morgenthau explains further; 'Within that mechanism, and within smaller mechanisms composing it, the mutual relations of the individual parts could be, it was believed, exactly determined by means of mechanical calculations, and the actions and reactions accurately foreseen.' ibid.
[244] ibid. pp. 161-2. Two points of interest here. First the quite static idea of 'equipoise' gained some currency. An example that adheres to a hard version of this, see George Liska, *Quest for Equilibrium: America and the Balance of Power on Sea and Land*, John Hopkins University Press, Baltimore and London, 1977. Yet others have suggested '*counterpoise*' to capture a level of dynamism. Sheehan, *The Balance of Power: History and Theory*, p. 110. Harold Nicolson, the British diplomat, diarist and politician, is one of a handful who not only contested this idea but touched on ideas commensurable to non-linear approaches. Derek Drinkwater, quoting from Nicholson, states that 'Nicolson envisaged the 'balance' as one characterized by dynamism. Fluidity, and changing power relationships between nation-states rather than a search for '"equipoise"'. Further, 'the balance of power comprises 'a multiplicity of sovereign states [which] tends to fall into unstable equilibrium, striving always for an even distribution, but constantly loosing it again'. Derek Drinkwater, *Sir Harold Nicolson and International Relations: The Practitioner as Theorist*, Oxford University Press, Oxford, 2005, p. 75.

For Morgenthau, the concept of balance of power came to represent a universal one, 'an essential stabilizing factor'. It is for him an ordering principle that permits a stable state-based international system to be conceptualised.[245] In a more circumspect way, Butterfield recognised its development and popularity as one of the more 'basic political formulas' stems from 'the modern world's reflection of its own experience'.[246] This is a partial admission that it is a theory devised to suit the worldview of the theory-maker. Consequently, upholding balance of power theory can be interpreted as an inadvertent *form* of paradigm defence, because the underlying assumptions continue to be drawn from the dominant meta-theoretical foundation.[247] Indeed, the traditional theories in IR, in their reductionist Newtonian moulds, have adopted 'a mindset of continuities that makes it difficult to address randomness', resulting in the perceived 'utility of ignoring the complexity of interactions'.[248] This could not be more relevant when discussing linear equilibrium projections and predictions. Moreover, as a concept, whether it be in economics, politics or international relations, it assumes a conservative nature: 'to say that various interests are "balanced" is generally to evaluate the *status quo* as satisfactory or even good; the hopeful ideal of balance often masquerades as fact'.[249] This certainly holds in respect to the structuralism of

---

[245] Morgenthau, *Politics Among Nations*, p. 161. On its existence in actual reality Morgenthau is quick to point out that 'Far from being invalidated by the fact that, for instance, a perfect balance of power policy will scarcely be found in reality, it assumes that reality, being deficient in this respect, must be understood and evaluated as an approximation to an ideal system of balance of power.' ibid., p. 8. However, it is still viewed as an entirely calculable concept. Take Walt's position that 'Balance-of-Power theory focuses on the distribution of material capabilities, such as population, economic wealth, natural resources, military forces etc. It predicts that states will balance against the *strongest* state, defined as the state with the largest accumulation of material sources, Stephen M. Walt, 'Keeping the World "Off-Balance": Self Restraint and US Foreign Policy' in G. John Ikenberry, ed., *America Unrivaled: The Future of the Balance of Power*, Cornell University Press, Ithaca and London, 2002, p. 124.

[246] Butterfield, 'The Balance of Power', p. 133.

[247] The paradigm defence occurs at the meta-theoretical level between the 'mature sciences'. See Kuhn, *The Structure of Scientific Revolutions*, esp. ch. 2.

[248] Kavalski, 'Emergence of Complex International Relations Theory', p. 446. He continues, quoting Michael Dillon (1996), 'The ambition of traditional IR to control reality epitomizes its 'closure of political thought, by reliance upon a technologized instrumentalization of it as representative-calculative thought'; whereas the endeavour of complexity research to account for articulations between the disciplinary fields concerns itself with the 'philosophy of the limit', which concerns itself with the operation of boundary—that is, the making of the human thought through the advent of boundary by thinking 'the very "inter" of the interval of being and not-being''. ibid.

[249] Mills, *The Power Elite*, p. 246. And of the international realm: 'So privileged nations condemn weaker ones in the name if internationalism, defending with moral notions what has been won by force against those have-nots whom, in making their bid for ascendancy or equality later, can hope to change the status quo only by force.' ibid.

neorealism, whose positivist assumptions 'treats the given order as the natural order'. [250] This inherent conservativism is basically a defining feature of negative feedback equilibrium models.

For the neorealist, international relations becomes even 'more scientific';[251] it 'is a progressive scientific redemption of classical realist scholarship',[252] with the idea of balancing becoming 'a scientific claim'.[253] Waltz declares outright that '[r]ealist theory predicts that balances disrupted will one day be restored'.[254] All there need be is anarchy and units 'wishing to survive'.[255] Some thinkers attempt to complicate Waltz's simple and elegant equation. For Walt, and here Wendt agrees, it is threats, not power, that 'states balance against'.[256] In Walt's view, threats 'are a function of power, proximity, offensive capabilities and aggressive intentions'.[257] It is an important point, and Keohane and Nye, with their neoliberal institutional argument, attempt to do likewise. For them the balance of power framework has changed. No longer is it just about military, brute power. Similarly, other variables, like the relative size of (and the resources within) the territory, of the economy and of the population suggest that the world is not so easily calculable according to traditional notions of international structure.[258] However, they are still bound by a two-dimensional view of power, that operates in an anarchical space in which the units act according to paradigmatic principles. The hard positivist edge may well have worn away, but the transference, as we saw above, does so via a different medium. The economic ontological perceptive linked, as it

[250] Ashley, 'The Poverty of Neorealism', p. 228.
[251] Thayer, *Darwin and International Relations*, p. 64.
[252] Ashley, 'The Poverty of Neorealism', p. 230.
[253] Wendt, *Social Theory of International Politics*, p. 18.
[254] Kenneth N. Waltz 'Structural Realism after the Cold War', *International Security*, vol. 25, no. 1, 2000, p. 28. The theory just 'cannot say when' balance will be restored. ibid. Once again, one can see the emerging ideas in *Man, the State and War*, ch. 7, esp. pp. 199-207.
[255] Waltz, *Theory of International Politics*, p. 121. Although Waltz has stressed that 'Balancing among states is not inevitable. As in Europe a hegemonic power may suppress it.' Waltz 'Structural Realism after the Cold War', p. 26.
[256] Wendt, *Social Theory of International Politics*, p 106. Wendt's views will be expanded upon in the next chapter in greater detail. He observes '[i]t seems doubtful that Canada is much worried these days about American threats to its security, or Britain about French threats' illustrates the differing nature of threat perception for social reasons. ibid.
[257] Walt, 'Keeping the World "Off-Balance"', p. 133. See also Stephen M. Walt, *The Origin of Alliances*, Cornell University Press, Ithaca and London, 1987, pp. 21-6.
[258] Keohane and Nye, *Power and Interdependence*, p. 196.

is, with rational choice theory, continues to dominate rationalist IR theories.[259] Waltz says outright that:

> Balance-of-power theory is microtheory precisely in the economist's sense. The system, like a market in economics, is made by the actions and interactions of its units, and the theory is based on the assumptions about their behaviour.[260]

However, the non-linear sciences offer a differing worldview. Waltz attempted to support his argument that a bipolar world creates the most stable balance of power by drawing an analogy with Poincaré's three-body problem. It could not be more ironic. Waltz argues that if the 'three-body problem has yet to be solved by physicist', then how can those who study international relations 'hope to do better in charting the course of three or more interacting states?'[261] Of course, as discussed in Chapter Two, the three-body problem is one of chaos theory's central ideas.[262] Poincaré's work was a precursor to Lorenz's meteorological modelling, which established concepts like sensitivity to initial conditions and the acceptance of randomness and bifurcation in dynamical systems.[263] Waltz, obviously, was not to realise the significance of his analogy and how the science behind that particular problem contributed to the development of the complexity sciences, which suggests that far-from-equilibrium processes are the norm in open dynamical systems. In light of this, a natural single point of equilibrium does not seem very natural. Curiously, when defining and describing the evolution of the importance of a social equilibrium, Morgenthau touches upon the possibility of multiple equilibria when shifted, momentarily, to the plural. It appears briefly in his *Politics Among Nations*, where he writes that 'the purpose of all such equilibriums [sic] is to maintain the stability of the system without destroying the

---

[259] Again, to qualify, in respect to the dominant rationalist theories and those that would oppose them.
[260] Waltz, *Theory of International Politics*, p. 118.
[261] ibid., pp. 192-3. Indeed, Waltz' argument of the greater stability of a bipolar world illustrates that his theory simply cannot escape its Cold War context. Little, *The Balance of Power in International Relations*, p. 210.
[262] See, for example: Gribbin, *Deep Simplicity*, pp. 14, 47-8; Aubin and Dalmedico, 'History of Dynamical Systems', esp. pp. 5-9; Barrow-Green, *Poincaré and the Three Body Problem*, passim.
[263] See, for example: Lorenz, 'Deterministic Nonperiodic Flow', pp. 130-41; Aubin and Dalmedico, 'History of Dynamical Systems', p. 30; Scott, 'Reductionism Revisited' p. 53.

multiplicity of the elements composing it'.[264] He is, however, incorrect in suggesting that it is the 'purpose'; with that comes a whole range of possible assumptions, but the concept touches on the nature of multiple systems co-existing within a nested framework. Multiple equilibria and the multiple points of attraction are where an order emerges from chaos.

Moving Away From an Equilibrium

If it is accepted, as Gaddis does, that many of the approaches that mainstream rationalist IR theorist continue to wrestle so unsuccessfully with have long since been abandoned by those theorising 'in the "hard" sciences',[265] then it is a small step to accept that the world has changed, or at least sped up and been released from those factors that dampened and mitigated turbulence. Both materially and ideationally, there exists an altered sense as to how the world is thought to function, and how it is thought to be imagined. In questioning the significance of the challenges of 'potentially radical new world orders', Renggar first points to how the '*material* features of the late modern world' are impacting global structures.[266] This is an acknowledgement of both the process of globalisation and the abundance of literature on the latter, but he also makes reference to similarly

[264] Morgenthau, *Politics Among Nations*, p. 163 Yet his 'equilibriums' fixate on traditional dichotomies and for finding the 'proper balance' on a diverse range of issues. He lists 'different geographical regions, such as the East and West, the North and South; between different kinds of activities, such as agriculture and industry, heavy and light industries, big and small businesses, producers and consumers, management and labor; between different functional groups, such as city and country, the old, the middle-aged, and the young, the economic and the political sphere, the middle classes and the upper and lower classes.' ibid., pp. 162-3. Waltz takes issue with Morgenthau's conception as, unlike his 'economic analogy' (which is really presupposed by an economic ontology), it assumes 'a necessary correspondence of motive and result and to infer rules for the actors from the observed results of their action.' Waltz, *Theory of International Politics*, p. 120.

[265] Gaddis, 'International Relations Theory', p. 55. Prior to this point Gaddis acknowledges the dominance of the Newtonian paradigm, also implicitly underscoring Kuhnian notions of paradigm defence, when he states 'The classical scientific method had been to generate laws, and hence predictions, from experiments that limited the number of variables involved and that controlled – sometimes quite arbitrarily – the conditions within which they operated. Newton's laws of motion, for example, assumed perfectly smooth balls rolling down frictionless inclines with no air resistance, a condition never actually encountered in the real world. Generations of students were taught that feathers and stones fall to earth at the same speed, despite the fact that they never really do. Predictability was achieved by removing the object being studied from its origins and its surroundings: one gained a vision of the future by shutting one's eyes to the past and present. But the more one observed past and present, the more Heisenberg's principle came into play, and the less confidence one could have in the forecasts made'. ibid., p. 54.

[266] Rengger, *International Relations, Political Theory, and the Problem of Order*, p. 10.

significant questions regarding how science has changed, and is changing, and the possible effects of this change upon the political.[267]

In this respect, globalisation has become a central issue for people and institutions across a broad section: academics, activists, policy-makers, big business, NGOs and governments are just some who are wrestling with the concept. Yet, as the literature in this area continues to expand, difficulties conceptualising it have not abated. Little has changed since Susan Strange described it as one of the more vague and woollier terms.[268] In a period that James Rosenau refers to as 'postinternational',[269] the challenge for IR theorists is to accept the uncertainty generated by this new phase, as opposed to trying to make it fit into pre-existing theories. Consider first, Giddens's often-quoted and widely-accepted definition of globalisation as being the 'intensification of world-wide social-relations which link distant localities in such a way that local happenings are shaped by events occurring many miles away and vice-versa'.[270] This represents a more than adequate starting point. However, it is also open to being augmented to shifts driven by complexity theory. For instance, a theory that either includes or is specifically about globalisation should also accept that the 'evolution of political-economic structures' is driven by the interaction of 'complex feedback effects'.[271] Rosenau's view is even closer to the mark, in that turbulence, as opposed to anarchy, has the power to effect change. It achieves this via global networks, which have increased exponentially in recent times. Increased also are complexity, dynamism and interconnectedness, all of which act as powerful positive feedback mechanisms that foster high energy and high turbulence in the international system.[272] For it to maintain its relevance, Giddens's definition needs to be

[267] ibid. He states: 'The models and methods of nineteenth- and early twentieth-century natural science – experimentation, falsifiability, predictability – are being augmented, some would say overwhelmed, but in any event changed by new worlds of chaos and catastrophe, or virtual reality and artificial intelligence, of bio- and nanotechnology and so on.' ibid.

[268] Susan Strange quoted in Ian Clark, 'Beyond the Great Divide: Globalization and the Theory of International Relations", *Review of International Studies*, vol. 24, 1998, p. 482.

[269] Rosenau, *Turbulence in World Politics*, ch. 1.

[270] Anthony Giddens, *Consequences of Modernity*, Polity Press, Cambridge, 1990, p. 64.

[271] Philip G. Cerny, 'Globalization and the Changing Logic of Collective Action', *International Organisation*, vol. 49, no. 4, 1995, p. 599.

[272] Rosenau, *Turbulence in World Politics*, p. 65.

expanded to accommodate this new theoretical thinking. In particular, if it is to be used for the analysis of international relations, it must incorporate the idea that the international system does not reside in, nor attempts to return to, a natural point of equilibrium. Modelski points out:

> …that world politics is neither an equilibrium (or near equilibrium) system, as postulated in traditional balance of power accounts, nor an anarchic one, in the sense of being chaotic, but it is in fact fluid, far from equilibrium, and flexible, one in which order arises through fluctuations.[273]

However, at this point confusion arises, as the notion of self-organisation, a staple of complexity theory, can be associated with equilibrium-seeking theories. The confusion partly arises because of the fact that theories of self-organisation and society, particularly in the realm of economics, predate any such theories in the sciences.[274] Linkages between the spontaneous order tradition of the Scottish Enlightenment and the concept of self-organisation are certainly recognisable.[275] The lack of intentionality in Smith's invisible hand bears a remarkable similarity to theories of self-organisation yet, at the same time, the invisible hand sits comfortably with Comte's positivism and displays a similarity with the social physics of Quetelet.[276]

---

[273] Modelski, 'Evolutionary Paradigm for Global Politics', p. 332.

[274] Witt, 'Self-Organization and Economics', p. 490. Even Waltz hints at a theory of self-organisation but quickly reverts to a theory of maximisation driven by selection. See Waltz, *Theory of International Politics*, pp. 75-7.

[275] It should be noted that Adam Ferguson's work on spontaneous order was far more reaching than that of Adam Smith. See Lisa Hill, 'The Invisible Hand of Adam Ferguson', *The European Legacy*, (formerly *History of European Ideas*), vol. 3, no. 6, 1998, pp. 42-65. Ferguson stated that "nations stumble upon establishments, which are indeed the result of human action, but not the execution of any human design", Ferguson quoted in Gus diZerega, 'Emergent Order and Liberal Political Theory', *The Good Society*, vol. 11, no. 3, 2002, p. 29.

[276] A. Carbone, G. Kaniadakisa and A.M. Scarfonea, 'Where do we Stand on Econophysics?', *Physica A: Statistical Mechanics and its Applications*, vol. 382, no. 1, pp. xi-xiv. In particular, they state 'A characteristic feature of the economics was the richness of interaction with natural sciences since its origin. The Wealth of the Nations, published by Adam Smith (1723–90), is usually considered to mark the beginning of classical economics. One century later, Adolphe Quetelet (1796–1874) corroborated the idea that physical laws could govern human behavior and also economics. His contemporary philosopher, Auguste Comte (1798–1857), first envisaged the social physics as a scientific discipline alongside astrophysics, geophysics and chemical physics. It is not by chance that these concepts rose in an intellectual climate permeated by the Newtonian ideas. The basic assumptions of neoclassical economics span a wide range of applications and concepts (utility maximization, market supply and demand, equilibrium) and are still influential.' This before coming to the conclusion that 'The increasing awareness of the inadequacy of the traditional methods of analysis has stimulated need for confrontation and interest towards the new

In the twentieth century, the work of Frederich von Hayek captured one side of this tradition of being able to know and understand a self-organising economic system as naturally arising phenomena beyond direct human control. In a 'Hayekian world', the market is nearly always close to 'correct',[277] and so a natural equilibrium remains paramount. From this it is asserted, by supporters of this tradition, that if the market is not close to correct, if the market errs, then 'planners cannot improve economic efficiency and will likely worsen it'.[278] However, some complexity researchers argue that planners are able to play a role. They will not necessarily 'fix' the economy, but it is thought that they may have an impact that ranges from worse, to better, to having no effect.[279] That is, depending on their ability to reconcile actions and reactions to any potential volatility within complex systems, there lies a continuum of possible outcomes. Holland was certainly not satisfied that the market, according to Smith's invisible hand, could account for the emergence that lessens fluctuations, dampening gluts and shortages in large, heavily networked and robust cities over longer timescales.[280] The common good, in the Smithian sense of it (and naturally arising through the actions of self-interested parties), becomes difficult to reconcile with claims to natural order. The notion of what is good and what is *the* equilibrium therefore become inextricably bound.

---

paradigms of thought even within the most traditional and conservative fringes of the economical and physical disciplines. New views and approaches are being tested and established allowing for interdisciplinary models of the economical human behavior, having as common denominator the fundamental dissatisfaction with rational agents and equilibrium', pp. xi-xii. See also Ball, *Critical Mass*, pp. 77-80.

[277] Henry E. Kilpatrick, Jr., 'Complexity, Spontaneous Order, and Friedrich Hayek: Are Spontaneous Order and Complexity Essentially the Same Thing?', *Complexity*, vol. 6, no. 4, 2001, p. 17. Mirroring an idea similar to the invisible hand, Hayek asserts his position: 'I am convinced that if it were the result of deliberate human design, and if the people guided by the price changes understood that their decisions have significance far beyond their immediate aim, this mechanism would have been acclaimed as one of the greatest triumphs of the human mind. Its misfortune is the double one that it is not the product of human design and that the people guided by it usually do not know why they are made to do what they do.' Frederich von Hayek, 'The Use of Knowledge in Society, *American Economic Review*, vol. 35, no. 4, 1945, p. 527.

[278] Kilpatrick, J, 'Complexity, Spontaneous Order, and Friedrich Hayek', p. 17.

[279] ibid. In respect to planning, bifurcation and sensitivity to initial conditions play a role and it is worth remembering that the further you think into the future the less certain you become. Basically, 'the planner extends the planning horizon, expected utility to the consumer rises but the risks of being drastically wrong increase if she is slightly wrong about the consumer's utility function.', Kauffman, *Origins of Order*, p. 399.

[280] Lansing, 'Complex Adaptive Systems', p. 183. Much earlier Karl Polanyi was similarly critical of the idea of self-regulating markets. See Vicki Birchfield, 'Contesting the Hegemony of Market Ideology: Gramsci's 'Good Sense' and Polanyi's 'Double Movement', *Review of International Political Economy*, vol. 6, no. 1, 1999, esp. pp. 36-40.

The result, of course, is that the common good is entwined with conservative behaviour in maintenance of the status quo, an idea easily interpreted by Gramscian arguments of common-sense.[281] From a classical realist perspective, Morgenthau certainly was not blind to the politicisation of the balance of power as a concept. He had no difficulty in admitting that ideologically-driven goals were often pursued under the pretence of either maintaining, or returning the system to a point of, balance.[282] As a contemporary example, consider how the then-Assistant to the President for National Security Affairs, Condoleezza Rice, articulated the idea of a balance of power:

> It calls on America to use our position of unparalleled strength and influence to create a balance of power that favors freedom. As the President says in the cover letter: we seek to create the 'conditions in which all nations and all societies can chose for themselves the rewards and challenges of political and economic liberty.'[283]

---

[281] For example, see Robert W. Cox, 'Civil Society at the Turn of the Millennium: Prospects for an Alternative World Order', *Review of International Studies*, vol. 25, no. 1, 1999, pp. 10, 27; Birchfield, 'Contesting the Hegemony of Market Ideology', pp. 27-54. One can also reflect, again, on Onuf's concept of order equalling privilege, only in this instance the rules of the game are constructed under the guise of maintaining a balance of power. In this sense balance of power is a fiction. See Onuf, *World of Our Making*, pp. 155, 159.

[282] Morgenthau, *Politics Among Nations*, p. 205. Morgenthau explains further: 'The use of the balance of power as an ideology accentuates difficulties inherent in the mechanics of the balance of power. Yet is must be noted that the ready use as an ideology to which the balance of power lends itself is not an accident. It is potentially inherent in its very essence. The contrast between pretended precision and the actual lack of it, between the pretended aspiration for balance and the actual aim of predominance – this contrast, which … is of the very essence of the balance of power, makes the latter in a certain measure an ideology to begin with. The balance of power thus assumes a reality and a function that it actually does not have, and therefore tends to disguise, rationalize, and justify international politics as it actually exists.' ibid. p. 207. See also Morgenthau's scathing article on US involvement in Vietnam as an example consequences of maintaining a perceived balance of power on ideological grounds; Hans Morgenthau, 'We Are Deluding Ourselves in Vietnam', *New York Times Magazine*, 18 April, 1965, pp. 24, 85-7. Even Waltz, before unconvincingly dismissing it, is forced to deal with ideology in a balance of power system. Waltz, *Theory of International Politics*, pp. 199-200.

[283] Condoleezza Rice, 'A Balance of Power That Favors Freedom', Wriston Lecture, Manhattan Institute For Policy Research, New York City, October 1, 2002, http://www.manhattan-institute.org/html/wl2002.htm, (accessed 16/03/08). It is not difficult to imagine in the light of such comments that a form of liberalism, or its neoclassical economic reincarnation, has sought to ascend to its *rightful* place at the 'end of history'. It is here that ideology, dangerously, becomes, in Vasquez conception, 'paradigm-producing'. Vasquez, *The Power of Power Politics*, p. 71. Indeed, a call to a democratic peace thesis routinely fails to acknowledge that 'democratic France and Britain had no trouble formulating the ideology (and offensive grand strategy) of imperialism and the "white man's burden." In addition, the United States had its grand strategy of manifest destiny'. ibid., p. 354. Kennedy also notes that this is not a new phenomenon with the rise of the United States in the late nineteenth century accompanied '… by an American-style *Weltpolitik*. Claims to a special moral endowment among the peoples of the earth which made American foreign policy superior to those of

Although the example above does call for what could be called a 'just balance',[284] it fails to escape the aforementioned thinking. Later in the same speech, Rice removes the mask of a just balance, indicating instead a traditional balancing behaviour. In doing so, she stated that '[w]e will seek to dissuade any potential adversary from pursuing a military build-up in the hope of surpassing, or equaling, the power of the United States and our allies'.[285] The issue here, hidden in Rice's assertion, is the continuation of international relations being imagined as a steady-state system which the major players drive to equilibrium. This, in turn, denies the possibility of accepting 'multiple equilibria' and the propensity for non-linear dynamics to influence outcomes.[286] In a 2005 speech, Rice, by then Secretary of State, captured an element, with disbelief suspended, of a how a more nuanced idea of power can lend itself to a far-from-equilibrium appreciation:

> In our time we have an historic opportunity to shape a global balance of power that favors freedom – and that will therefore deepen and extend the peace. And I use the word 'power' broadly, because even more important than military and indeed economic power is the power of ideas, the power of compassion, and the power of hope.[287]

However, even here, linear orthodoxy has not been supplanted. Her speech, if accepted at face value, offered a reconceptualisation of power, with a depth

---

the old world were intermingled with Social Darwinistic and racial arguments… The traditional, if always exaggerated, alarm about threats to the Monroe Doctrine was accompanied by calls for the United States to fulfil its 'Manifest Destiny'.' Kennedy, *The Rise and Fall of the Great Powers*, p. 317.

[284] The idea of a 'just balance' first received mention in the Treaty of Utrecht: 'Art. II of the treaty of peace and friendship between Great Britain and Spain of July 13, 1713. "A just balance of power" (*potentive œquilibrium*) was declared to be the best and specially solid basis of mutual friendship and lasting concord.' Myers, 'The Bases of International Relations', p. 438. This idea encapsulates the idea of fair and equal balance. Sheehan, *The Balance of Power: History and Theory*, p. 16. On the idea of a just equilibrium (utilising a Rawlsian approach) see Manus I. Midlarsky, 'The Balance of Power as a "Just" Historical System', *Polity*, vol. 16, no. 2, 1983, pp. 181-200.

[285] Rice, 'A Balance of Power That Favors Freedom', URL. Again supporting the idea that the theory of balance of power operates as a means to justify ideological perspectives and political decisions. Richard Cobden, in the nineteenth century, pre-empting much later arguments tied to the power of the military-industrial complex, argued that the idea of maintaining a balance of power operates as a justification for increasing defence spending and maintaining large standing armies. Cobden, *Political Writings*, p. 111.

[286] Chatterjee and Yilmaz, 'Chaos, Fractals and Statistics', p. 62.

[287] Condoleezza Rice, 'Remarks at the Institut d'Etudes Politiques de Paris - Sciences Po' Paris, France, February 8, 2005, US Department of State, http://www.state.gov/secretary/rm/2005/41973.htm, (accessed 16/03/08).

beyond Lukes's first two dimensions. Ultimately, however, this is a ruse. Although it can be favourably viewed as an important step beyond realist-driven foreign policy, it should perhaps be viewed instead as an attempt to 'control' the perception of an equilibrium. It is an account of the notion of balance of power account that accepts a normative element of what is good. Exposed, on the one hand, is the poverty of the science of economics as a base, whilst, on the other hand, it reveals the social construction of norms of behaviour.

To continue the critique of neoclassical derived notions of equilibrium, whether based upon myths, models or metaphors,[288] the restrictive logic needs to be further exposed. Effectively, theory construction that draws from the 'classical theory of Marshall and Adam Smith' is fixated on finding a 'unique equilibrium value', the issue being that this denies the incorporation of positive feedback.[289] In this regard, development, in the case of economics, or major change, in respect to structures of international relations, simply cannot be explained with any level of ease. The mechanistically-inspired mathematics of general equilibrium theory, if indicative of a law even in the loosest sense, means that a significant change away from equilibrium cannot occur because the agents, whether they are states or economic units, will be consistently punished.[290] A conservative system (that is, one that is non-dissipative, as formulated by many traditional theories) would behave in a consistently linear fashion. Robert Jervis, a realist scholar who has absorbed some of the lessons from complexity theory, acknowledges this point in his work, noting that in the absence of 'positive feedback there could be no change or growth'.[291] Given the propensity for global shocks, it becomes apparent that this is not the case. However, understanding from a complex perspective acknowledges that boundaries are present (and are generated) by away-from-equilibrium processes.[292] That boundaries are generally stable and allow for 'the

[288] On the nature of 'metaphors and myth-making' upon the development of different models of balance of power see Little, *The Balance of Power in International Relations,* esp. ch. 3.
[289] Chatterjee and Yilmaz, 'Chaos, Fractals and Statistics', pp. 61-2.
[290] Witt, 'Self-Organization and Economics', p. 498.
[291] Jervis, *System Effects*, p. 125.
[292] Not to labour the point, but the 'traditional mathematics used in economics' is challenged, it is argued, by complexity theory. Arthur, Durlauf and Lane presented the following six principles, the so-called 'Santa Fe

continuities of political life'[293] should not be conflated with a theory of equilibrium, with the only 'natural order' being that which is far-from-equilibrium:[294]

> Complex social systems are never homeostatic: in both markets and world politics the frequent and temporary equilibrium points are always distinct phenomena. Each state of balance, like a human standing still through tensions between opposing muscles, is a fleeting event within a specific set of conditions, a point on a path of change.[295]

If points of attraction, the so-called strange attractors, direct the flow of energy or power to points away from an idealised notion of equilibrium, how then is the rational actor expected to act? The result of all this is that progress, as framed by rationalism, is threatened if individuals stop acting rationally. This is the impact that occurs at the theoretical level, with the social influences that individuals, states, or institutions are exposed to being effectively ignored.[296] Yet somehow 'progress' still continues. Traditional economics and social theories that form a part of this worldview must acknowledge that agents are of 'bounded rationality', as opposed to the 'perfect rationality' predicated by neoclassical economics.[297] Further to this, a 'high a priori fitness' cannot be assigned to an aggregate (e.g. the state) as the 'fitness must emerge from the context',[298] a concept easily married to the Wendtian idea of corporate agency.[299] With this in mind, Waltz's elegant theory of neorealism, built upon its microeconomic base, runs into serious

---

Approach', that capture how a complex adaptive system like an economy should be properly examined/imagined: '1. Dispersed Interactions, 2. No Global Controller, 3. Cross-Cutting Hierarchical Organization, 4. Continual Adaptation, 5. Perpetual Novelty, 6. Out-of-Equilibrium Dynamics'. Quoted in Kilpatrick, Jr., 'Complexity, Spontaneous Order, and Friedrich Hayek', p. 17.

293 Rosenau, *Turbulence in World Politics*, p. 10.

294 Drawing on Toulmin, Jervis attempted to treat 'balance' and 'consistency' within a system as synonymous yet is misleading as it could quickly be subsumed by what is thought to be natural with status quo conservative defence quickly coming into play. See Jervis, *System Effects*, pp. 210-11.

295 Harrison, 'Thinking About the World We Make', p. 11.

296 Barnes, 'Thomas Kuhn', p. 86.

297 Holland, *Hidden Order*, p. 85. See also Arthur, W. Brian, 'Positive Feedbacks in the Economy', *Scientific American*, vol. 262, no. 2, 1990, pp. 92-99,

298 ibid., p. 98.

299 See Wendt, *Social Theory of International Politics*, ch. 5. Wendt view is, of course, state-centric and any marriage would have to properly incorporate how feedback and far-from-equilibrium processes would shape the aggregate. See following chapter for an elaboration.

conceptual difficulties. Lars-Erik Cederman, in his efforts to resuscitate structural realism through the methodological insertion of complexity theory, admitted to a fundamental part of these difficulties:

> At the level of general theorizing, Waltz (1979) epitomizes this transfer of analogies by stressing the prevalence of negative feedback and rationality in history. Yet if [self-organised critically] is a correct guide to interstate phenomena such as war, it seems less likely that static frameworks such as that suggested by Waltz are the right place to start in future attempts to build systems theory. In fact, his sweeping anarchy thesis remains too vague to be particularly helpful in explaining particular wars or any aggregate pattern of warfare for that matter (Vasquez 1993). This reasoning does not render realist analysis of warfare obsolete, but it does tell us that such theorizing needs to rest on explicitly spatiotemporal foundations.[300]

The importance here lies not in the success or lack of it in respect to the reincarnation of realism, but with the importance on the 'spatiotemporal foundations'. It is within this space that points of attraction are articulated. The far-from-equilibrium strange attractors nestle into such spatial-temporal understandings. This therefore accepts that multiple points of attraction occur within this imagined space, with some more dominant than others, but each influencing the other in some capacity. The difficulty for rationally-based theories is that open non-linear systems will primarily move through this phase space (or fitness landscape[301]) in ways that are not always foreseeable, with such

[300] Cederman, 'Modeling the Size of Wars', p. 145. Cederman feels that self-organised critically offers the best avenue with it being a superior analogy to 'either the billiard balls of classical physics or the "butterfly effect" of chaos theory'. Indeed, he correctly targets the 'ahistorical' nature of pool tables but has a potentially ill-informed shot at 'intractable turbulence'. ibid. p. 146. In its entirety, he feels that 'Earthquakes, forest fires, biological evolution, and other historically formed complex systems serve as better metaphors for the broad picture of world history than "ahistorical" pool tables or intractable turbulence.' ibid. He's quite right to target deterministic chaos but presumably his target it qualitative methods as opposed to Rosenau's notion of turbulence in international affairs.

[301] The implication here is 'that a landscape may change to create new 'basins of attraction'', Kauffman in Tim Blackman, 'Complexity Theory' in Gary Browning, Abigail Halcli and Frank Webster, eds., *Understanding Contemporary Society: Theories of the Present*, Sage Publications, London, 2000, p. 147.

movements dependent on the immediate and longer-term effects of both positive and negative feedback.[302]

This is what Kauffman attempted to identify as the 'poised' state between order and chaos.[303] It is here that theories of IR can start the process of imagining the international system from a different conception of how order arises. For instance, to return to the example of globalisation, it can be argued that if the system is permitted to move towards the chaotic or 'noisy' end of the spectrum, then free markets, unfettered by any consideration beyond their own 'locality', could move the international system towards an unsustainable position. Indeed, unfettered globalisation may well fail to 'strengthen global *laissez faire*' by undermining the very 'social institutions that allow free markets to flourish'.[304] Planning, regulation, redistribution or merely curtailing excesses can be legitimised as playing a necessary role at the domestic level, with an argument supporting the strengthening norms and institutions viable in the international setting. This is not to say that a complexity-inspired approach prescribes such measures, but it is an indication as to how it might inform theory-making, in this case, conceivably, neoliberal institutionalism.

Conversely, it has been suggested by some complexity theorists that the former Soviet Union collapsed because its centralised economy and bureaucracy 'was too

[302] This is especially true of capitalist based international system. See Yong Pil Rhee, 'Chaos and Order Through Fluctuations in Global Capitalism in the Twenty-First Century', *Systems Research and Behavioral Science*, vol. 20, no. 5, 2003 pp. 427-433.
[303] See Chapter Three. See also Kauffman, *Origins of Order*, pp. 29-30, 218-21; Kauffman, *At Home in the Universe*, p. 15. On the one hand as Kauffmann points out, 'coevolving of complex systems', with selection processes, are strongly indicative of an invisible hand-type phenomena that 'forms an ecosystem whose members mutually attain the edge of chaos'. Kauffman, *Origins of Order*, p. 29. See also Kauffman, *At Home in the Universe*, p. 262. Kauffman is unaware as to the consequences of providing a rapport with a notion of a general equilibrium; See Hodgson, 'Economics and the Return to Mecca', pp. 399-412; Ackerman, 'Interpreting the Failure of General Equilibrium Theory', pp. 119-39; Colander, 'The Death of Neoclassical Economics', pp. 127-43. This is despite the fact that he has been critical of classical economics elsewhere; For example see Kauffman, *Origins of Order*, pp. 210, 255-6; Kauffman, *At Home in the Universe*, p. 270. Further, he does not allow for the chaotic versus ordered interpretations of an ecosystem, which is scaled and contains multiple equilibria, to shine through (his thoughts here represent more of a grappling to identify with what he perceives a similar notions outside of his field). See Levin, 'Self-Organization and the Emergence of Complexity, p. 1076; Prigogine and Stengers, *Order Out of Chaos*, p. 169.
[304] James W. Thomson, 'Globalization: Obsession or Necessity?', *Business and Society Review*, vol. 104, no. 4, 1999, p. 404.

stagnant, too locked in, too rigid to survive'.[305] Complexity theory further supports the notion that the 'centralised approach to the organisation of society does not work' due to the highly ordered nature of the system.[306] This is not necessarily a surprising or novel perspective, given that Hayek had made similar observations.[307] Concessions do need to be made in that the Soviet economy needs to be placed in time and context. For one, it can be argued that a command economy can have states that range from 'bad' to 'good' (within, of course, phase space[308]) that are dependent on how 'particular circumstances may have pushed Soviet institutions from one to the other'.[309] However, the abandonment of the 'monitoring regime' from 1989[310] highlighted the 'failure of the administrative structures and institutions of modern communist states', which, in turn, 'led to the failure of communism as an ideal, and as a sustainable political system'.[311] Again, this is not a decree *of* complexity theory, but an admission that order exists, like power, in a complex matrix of interdependencies and it is contextual and historicised.

Hence, it is argued that complex systems 'learn' how to 'balance divergence and convergence, so that they're poised between chaos and order'.[312] This necessitates an appreciation that systems, like the international system, function 'at the "edge of chaos" but are not themselves chaotic'. Furthermore, there is an inherent ability

---

305 Waldrop, *Complexity*, p. 294.
306 ibid. Indeed, Urry notes that even the introduction of new technology like photocopiers and personal computers undermined the centralised control of the Soviet regime. Urry, 'The Complexities of the Global', p. 236. Differently, it has also been suggested that during the 1970s Detroit's 'Big Three' automakers fell victim to their own structure. They had become large, rigid behemoths that were locked into specific (and antiquated) methods that denied them the ability to identify the increasing threat from Japan. ibid. p. 294. Tied in, with the concept of increasing returns the sudden rise of Japanese small cars became a self-reinforcing mechanism. It was not just the singular effect of a positive feedback loop, as the initial gains were supported by the flexible and adaptive methods of the Japanese auto industry. Arthur, 'Positive Feedbacks in the Economy', p. 95.
307 See Hayek, 'The Use of Knowledge in Society', pp. 519-30.
308 See discussion on phase space and basins of attractions in Chapter Three.
309 Mark Harrison, Coercion, Compliance, and the Collapse of the Soviet Command Economy', *Economic History Review*, vol. 55, no. 2, 2002, p. 402.
310 ibid. p. 428.
311 Chris Goldspink, 'Contrasting Linear and Nonlinear Perspectives in Contemporary Social Research', Emergence, vol. 2, no. 2, 2000, p. 85.
312 Stuart Kauffman, 'Order for Free' in John Brockman, ed., *The Third Culture: Beyond the Scientific Revolution*, Simon & Schuster, 1995, http://www.edge.org/documents/ThirdCulture/zd-Ch.20.html accessed 19/4/04.

for the system to change and 'to adapt to new conditions' within this conceptualised space.[313] Situations become increasingly complex when driven by feedback processes, particularly if actors fail to grasp the extent to which or how 'their behaviour will alter what others do' or fail 'to appreciate that others as well as they will react to a changing environment'.[314] Thus, unpredictability is inherent, knowledge is never complete, history and other social factors inform decision-making, and the consequence of actions, or inactions, not only feed-back and re-inform, but the process as a whole is irreducible. The argument then supports the position that a revelation of this nature should act, as outlined in the previous chapter, as a presupposition if attempting to construct or re-imagine theories of IR. In this light, theories should develop:

> an appreciation that any small event or the initial conditions of any situation can upset normal routines and the prevailing equilibrium – people in all the local, global, and private worlds are likely to yearn for stability and, in doing so, to treat stable conditions as an objective reality. But stable equilibria not only consist of highly delicate, and fragile balances; they are also profoundly and thoroughly the focus of normative preferences.[315]

By moving paradigmatically to the complexity sciences, the world can be comprehended as being socially constructed but not reified, and one can accept an 'engagement of science with reflexive social action'.[316] The multiple trajectories of agents within the system collect around points of attraction within a phase space (again the state is the most obvious example, but not the only example). Moreover, agents are defined by their histories, which contribute to, and are a part of, the

---

313 Modelski, 'Evolutionary Paradigm for Global Politics', p. 332; see also Waldrop, *Complexity*, pp. 224-235, 292-294. On the occurrence of change and periods of volatility (that is, those periods that do not neatly fit into a status quo notion of order), Rosenau's turbulence argument captures how it might be imagined: 'When the system's boundaries no longer contain the fluctuations of the variables, however, anomalies arise and irregularities set in as structures waiver, new processes evolve, outcomes become transitory, and the period enters a period of prolonged disequilibrium'. Rosenau, *Turbulence in World Politics*, p. 8.
314 Jervis, *System Effects*, p. 259.
315 Rosenau, *Distant Proximities*, p. 223.
316 Byrne, 'Complexity, Configuration and Cases', p. 99.

constant and simultaneous changes and continuities.[317] Power, order and anarchy influence and contextualise agents and structures in this space, resulting in the continual reshaping of the international system as part of a non-linear dialectic process.[318] To use Kauffman's term, a 'walk in parameter space' is undertaken whenever the system moves towards a chaotic phase.[319] At some point a 'poised' state will re-emerge. The traditional concept of balance of power simply does not capture the complex and continually dynamic nature of this process. An emergent order far more accurately describes the situation.

Conclusion

The introduction of complexity and its underlying principles allows for a new perspective that does not shy from unpredictability. Its focus is instead on observing they way in which interactions take place and the 'space' in which the system resides. The ideas represent an explicit gathering of ideas that have been supported by research in the non-linear sciences,[320] the fruits of which have only in recent times started to make an impact in IR theory. Consider that Kant imagined an idea of equilibrium that incorporated a 'self-reinforcing positive feedback' process, that is, a dialectic driving norms, socialisation and competition 'away from a convergence around a structural equilibrium'.[321] This could be understood as an early recognition of far-from-equilibrium processes. However, Kant, who was very much a product of the Enlightenment, hoped that these dynamics would 'compel our species to discover a *law of equilibrium* to regulate the essentially healthy hostility which prevails among states'. [322] For Kant's dream to become a reality, the unpredictability of complex feedback effects would have to be abandoned. Gaddis, again, captures the sentiment:

[317] See ibid., p. 105. Indeed 'Change and Continuity' formed part of the subheading for Rosenau's groundbreaking book *Turbulence in World Politics*.
[318] See J. Barkley Rosser Jr., 'Aspects of dialectics and non-linear dynamics', *Cambridge Journal of Economics*, vol. 24, no. 3, 2000, pp. 311-24.
[319] Kauffman, *Origins of Order*, p. 210.
[320] Goldstein, 'Emergence as a Construct: History and Issue', p. 40.
[321] Harrison, 'Waltz, Kant and Systemic Approaches to International Relations', pp. 151, 153.
[322] ibid., p. 152. With some reframing, Harrison's belief that the 'Kantian view of that the Enlightenment offered by social scientific explanation … may take on renewed historical significance' ibid., p. 161.

> Surely human affairs, and the history they produce, come closer to falling into the unpredictable rather than the predictable category: not only are the potentially relevant variables virtually infinite, but there is the added complication – not found in either clouds or clocks – of self-awareness, which means that the 'variables' themselves can often foresee the consequences of contemplated actions, and reconsider them accordingly.[323]

This chapter has argued that the preoccupation with anarchy and power in the study of international relations has been conjoined with a long-standing desire to create theories that display order and neatness via simplification and reductionism. It argued that the Newtonian paradigm, however implicit, and often transferred via an economic ontological understanding, skews images of global politics, and results in many rationalist-based theories searching for a theory of natural equilibrium. Instead, theories of international relations should embrace multiple points of equilibria that push toward different points of attraction. Moreover, the dominant theories of IR need to release themselves from their 'reactionary stance' and consent to the 'emancipatory' possibilities tied to complexity theory.[324] Indeed, to adhere to a strict rationalist conception also runs the risk of squeezing out the '"historical" voice'.[325] On the other hand, the swing of the pendulum too far into the radical reflectivist camp results in a position that is open to the accusation of being devoid of 'any intelligible meaning'.[326] What is sought is a path that can both explain and accommodate normative conjecture. A friction exists here, and it is one which Morgenthau wrestled with throughout his career:

[323] Gaddis, 'International Relations Theory', p. 29.
[324] Kavalski, 'Emergence of Complex International Relations Theory', p. 450.
[325] Rengger, 'Political Theory and International Relations', p. 769. Quoting English conservative philosopher Michael Oakeshott, Rengger concludes that 'the [rationalist] first turns off the light and then complains that he cannot see'. ibid., p. 770.
[326] Guzzini, 'A Reconstruction of Constructivism in International Relations', pp. 147-48. What du Plessis has referred to as 'the 'slash-and-burn' extremism of some post-modern thinkers', du Plessis, 'International Relations Theory and the Discourse on Terrorism', p. 143; And Wendt with his soft constructivism says: 'The external world to which we ostensibly lack access, in other words, often frustrates or penalizes representations. Postmodernism gives us no insight into why this is so, and indeed, rejects the question altogether'. Wendt, *Social Theory of International Politics*, pp. 56-7.

> His vast academic production displays a virtually constant tension between, on the one hand, his desire to explain international politics from a scientific point of view, and on the other hand, his equally strong urge to engage in normative political theory and advise American statesmen on the requirements for successful as well as morally responsible statecraft.[327]

Although fixed to a state-centric model, Morgenthau's desire becomes less fraught with the removal of the certainty of a consistent and natural equilibrium.

[327] Stefano Recchia, 'Restraining Imperial Hubris: The Ethical Bases of Realist International Relations Theory', *Constellations*, vol. 14, no 4, 2007, p.535. Moreover, 'in his best-selling classic *Politics Among Nations* (first edition 1948), Morgenthau deliberately attempted to construct a general positive theory of international relations, with relatively simple, law-like propositions derived from historical experience.' ibid. p. 536.

5

Nested Worlds and International Emergence

But two times two makes four is an insufferable thing, nevertheless. Two times two makes four – why, in my opinion, it's mere insolence. Two times makes four stands there brazenly with its hands on hips, blocking your path and spitting at you. I agree that two times four is a splendid thing; but if we're going to lavish praise, then two times five is also a very charming thing.[1]

This final chapter pulls the components of a complexity worldview together and argues that the international system is nested in nature, with multiple complex adaptive systems being present. Within this multi-dimensional space, dominant points of attraction, like the state, occur. Similarly, dominant processes are recognisable, globalisation being an obvious example. The chapter concludes by arguing that a non-linear understanding will support theories of international relations. Yet, this support is conditional upon surrendering positivist assumptions of linearity, reductionism, and predictability from additive conjecture. Moreover, the belief that intersubjective relationships are of little

[1] Fyodor Dostoyevsky, *Notes From the Underground*, Michael R. Katz, trans. and ed., W. W. Norton & Company, New York and London ,1989 [1864], p. 24.

relevance must be abandoned.[2] Consequently, the argument centres on accepting complexity theory and, more generally, the non-linear sciences as a 'meta-theoretical commitment'.[3] In doing this it becomes equally important to ensure that the study of complexity does not fall into isomorphic dalliances,[4] a danger that too often becomes realised with methodological applications or simplistic acceptance of non-linear phenomena as an accurate description of the world based upon assumed similarities.[5] The use and abuse of complexity theory is not entirely unexpected, given its appeal in popular science literature and its ability to provide quasi-legitimacy to fields of study looking for scientific affirmations.[6] It is similarly necessary to posit that although the emergence of complexity theory, as a distinct school of thought and as a means of qualitative analysis within international relations, is a relatively new approach, many thinkers have long shared the underlying principles of complexity-related research.[7]

The chapter sets outs its case in five stages. First, it is argued that there is an ontological depth to how international politics should appropriately be considered. Presented here is an image of complex interaction, whereby multiple and interconnected groups that have different degrees of permeability and connectivity are dynamically interrelated, which results in the emergence of points

[2] For example, to again scapegoat Morgenthau, his assertion that 'Intellectually, the political realist maintains the autonomy of the political sphere, as the economist, the lawyer, the moralist maintain theirs. He thinks in terms of interest defined as power, as the economist thinks in terms of interest defined as wealth; the lawyer, of the conformity of action with legal rules; the moralist, of the conformity of action with moral principles' captures how delineation lies at the heart of the problem. Morgenthau, *Politics Among Nations*, p. 11.
[3] With thanks to Stefano Guzzini who brought this possibility to my attention via an email discussion.
[4] Neil E. Harrison, 'Complex Systems and the Practice of World Politics' in Neil E. Harrison, ed., Complexity *in World Politics: Concepts and Methods of a New Paradigm*, State University of New York Press, Albany, 2006, p. 186.
[5] What is clear in such instances is that 'complexity theory is a child of the Enlightenment and carries with it some of the baggage of "Westerncentrism"', Stewart, 'Complexity Theories, Social Theories', p. 334. It should also be re-enforced that Lorenz, in establishing his theory of sensitive dependence to initial conditions, highlighted the error of assuming analogues in natural phenomena that drew on linear understandings of the world. Lorenz, 'Deterministic Nonperiodic Flow', p. 141.
[6] See Stewart, 'Complexity Theories, Social Theories', p. 329.
[7] Rosenau, *Distant Proximities*, p. 207. As Kavalski outlines the idea of complexity has in some formed started the process of permeating across discourses within IR so to account for intricacies, interdependencies and, at the very least, the implicit acceptance of feedback processes that are not easily regulated by linear theories. In a far from exhaustive list Kavalski refers to Joseph Nye's 'complex interdependence'; Alexander Wendt 'complex learning'; Goodhand and Hulme's 'complex political emergencies'; Ken Booth's 'complex security'; Flockhart's 'complex socialization'; Bouris 'complex political victims'. Kavalski, 'Emergence of Complex International Relations Theory', p. 441. 'Indeed, the pace and multidirectional transformations in international life have necessitated looking beyond linearity', ibid.

of order and attraction. This supports the argument that any analysis of international relations should be sensitive to multiple and overlapping worlds that are better understood as being nested.[8] Second, the argument pursues the importance of appreciating that multiple groups can emerge and interact within the same 'space', irrespective of the existence of a dominate aggregate (i.e. the state).[9] Indeed, the ability for macro change to occur as a bottom-up process via differing groups or even individuals should not be ignored. Groups, or socially constructed aggregates, are important, and it is argued that the state is an enduring (if multifarious) and widely accepted example of this process.[10] Yet, it is of equal importance to accept that all aggregated groups and communities change and differ in significance over time, and that they should not be rooted in the scientific certainty of immutable boundaries or equivalence to a base unit. In this respect, the state, as a political unit, can be considered as a lasting aggregation that has developed as the core building block of a Newtonian understanding of the international environment. It is here that a level of re-imagination is required.

The third element closely follows, by examining the interplay between agency and structure. Exposed are dominant rationalist projections of the nature of states, and developed simultaneously is the argument that order and aggregates will *always* emerge and re-emerge as part of a complex dialectic in the international system.[11] Moreover, emphasised is the point that it is incorrect to assume that particular forms, functions or norms will always endure, or that they in themselves have come to represent ultimate realities or points of explanation. Indeed, the significance of particular intersubjective-interrelationships contribute to the

[8] As opposed to traditional hierarchical and/or linear assumptions.
[9] For example take the 'phrase *ubi societas, ibi jus* – where there is society there is law', a phrase that recognises that law is a social product and it does not necessitate a teleological understanding. Jesse S. Reeves, 'International Society and International Law', *The American Journal of International Law*, vol. 15, no. 3, 1921, p. 368. This can be taken to mean that 'every system has its own society, or to put it another way, every legal system is a normative regulatory subsystem of a wider social system and the character, independence and distinctiveness of legal systems depends on the character, degree of independence and distinctiveness of these wider social systems. *Ubi jus, ibi societas.*' Rein A. Müllerson, *Ordering Anarchy: International Law and International Society*, Martinus Nijhoff Publishers The Hague, 2000, p. 88.
[10] On the aggregation (and disaggregation) of social groups see Rosenau, *Turbulence in World Politics*, ch. 7.
[11] Rosenau also argues that there exists an underlying order in world politics. See Rosenau, *Turbulence in World Politics*, Ch. 3, esp. pp. 48-52.

establishment and emergence of what might be considered the most appropriate 'elements' when theorising the international system. Of course, the formation of any such 'elements' is a continual process of regeneration between, for example, component parts, subsets, structure and agency, or the ideational and the material. Beyond this, the chapter moves towards its fourth stage, pointing to the necessary acceptance of understanding the international system/society as a global complex adaptive system or systems. With this comes the idea of open, complex dynamical and emergent systems that can be imagined as accepting a commonly appreciated space but are nonetheless able to undergo rapid and unpredictable change.

The final stage of the argument is to celebrate the release of imagination, intuition and interpretation from its prison. The mind of the artist and the mind of the scientist (and all those minds that could be imagined as existing in between) need not be separated when considering social phenomena. Overall, the chapter puts forward that a non-linear paradigm will preserve the importance of intuition and interpretation to the study of international relations, but to do so without being deemed irrelevant for lack of a scientific base, or being accused of 'physics envy' because of its scientific base. In constructing this challenge to orthodox worldviews of international relations, undone is the fixation derived from nineteenth century ontological presuppositions which saw the merging of teleological desire for scientific certainty.[12] In developing the argument, the chapter continues the critique of the dominant rationalist theories. It critically engages with Wendtian constructivism, and illustrates how a meta-theoretical commitment to complexity theory can reinvigorate theoretical approaches in IR. Context and contingency, supported by presuppositions derived from non-linear science, return and reshape how the world might be considered.

[12] For example see Michael Polanyi, 'Scientific Outlook: Its Sickness and Cure', *Science*, vol. 125, no. 3246, 1957, pp. 480-484.

Nesting, Layers, and Overlaps

On coming to power, the George W. Bush administration, demonstrating a realist orthodoxy, considered US primacy to be sufficient to maintain a desirable world order. The calculated and rational deliverance or threat of power is, of course, a mainstay of this worldview. Yet, the actions of a shadowy terrorist network on 11 September 2001, and much of the subsequent fallout from the unilateralist policies pursued by the US, revealed the vulnerability of this position.[13] In many respects, the watershed of September 11 oversaw a significant transformation in US foreign policy, from one guided by essentially realist principles to the hawkish idealism of the neo-conservatives.[14] However, the approaches are not altogether dissimilar. Central to the outlook of either perspective is the desire to generate outcomes derived from the capability to project power. The nature and use of this power is reflective of the first and second dimensional power discussed in the previous chapter. The issue is that the idea of attempting to 'control' a complex system, like the international system, via the might of an individual country, defies the very nature of how order arises.[15] It is, arguably, a mistake to locate power simply in the decisions of the powerful. The reductionism of power politics[16] exposes its Newtonian roots.

Of course, it is not just realism, or the curious liberalism of neo-conservatives,[17] For example, Jervis is correct in asserting that dependency theory, which reached

[13] Stefano Guzzini, 'Foreign Policy Without Diplomacy: The Bush Administration at a Crossroads', *International Relations*, vol. 16, no. 2, 2002, p. 296. Not least for having to confront violent non-state actors.

[14] See, for example: Fukuyama, Francis, 'Beyond Our Shores', *The Wall Street Journal*, December 24, 2002, p. A10; Brian C. Schmidt and Michael C. Williams, 'The Bush Doctrine and the Iraq War: Neoconservatives Versus Realists', *Security Studies*, vol. 17, no. 2, 2008, pp. 191-220; John Mearsheimer, 'Hans Morgenthau and the Iraq War: Realism Versus Neo-Conservatism', *Open Democracy: Free Thinking for the World*, 18 May 2005, http://www.opendemocracy.net/node/2522/pdf, date accessed 26/12/2007. For a Gramscian overlay see Piki Ish-Shalom, 'Theory as a Hermeneutical Mechanism: The Democratic-Peace Thesis and the Politics of Democratization', *European Journal of International Relations*, vol. 12, no. 4, 2006 pp. 565-98. For a good overview of how the Bush administration's response to September 11 has damaged their legitmacy see Martin Griffiths, 'Self-Inflicted Wounds: United States Grand Strategy and the War on Terror', refereed paper presented to the Australasian Political Studies Conference, University of Tasmania, Hobart, 29 September – 1 October, 2003.

[15] Indeed, even the conceptualisation of a single international system becomes difficult.

[16] Wendt, 'Anarchy is What States Make of it', p. 408.

[17] Although neo-conservatives are critical of 'liberalism' or 'liberals' their philosophical root, to which they are generally amendable to, can be located in the 'classical liberalism' of the Enlightenment (in particular the Scottish Enlightenment). Michael C. Williams, 'What is the National Interest? The Neoconservative Challenge in IR Theory', *European Journal of International Relations*, vol. 11, no. 3, 2005, pp. 315-6.

its height in the 1970s, is a theoretical approach that is 'too systemic in its view of the degree to which external forces control the fate of states' and, moreover, 'it underestimates the power and autonomy of even weak states'.[18] Here, power is awarded to the structure of the system. Structure embodies a 'scientific' Marxist perspective; an idea that restricts agency. To quote Marx: 'Men make their own history, but they do not make just as they please; they do not make it under conditions chosen by themselves'.[19] A little differently, this is reminiscent of Leo Tolstoy's *War and Peace*, where the many actors are helpless to the drive of history: historical laws exist in his deterministic world.[20] To push it to an extreme, the world is reduced to a deterministic operating system.[21] Power contributes to order, but it should not be deemed progressive, determinable, or reducible in theoretical terms to prescribe what is actually 'out there'.

It is here that realism, as an explanatory theory that explains how the world *is*, can be critiqued. Vasquez noted that Morgenthau, with his delineated 'general "laws",' provided IR scholars with 'the fundamental units that compose the world', the manner in which 'they interact', and 'what conception of the world should be employed to answer … questions'.[22] On the surface there is nothing necessarily wrong with this process of abstracting. There understandably exists a desire to simplify to a level that permits an ease of understanding, and to develop

---

[18] Jervis, *System Effects*, p. 103.

[19] Marx quoted in Wight, 'Philosophy of Science and International Relations', p. 24. On the intersection between scientific thought and Marxism, see H. Floris Cohen, *The Scientific Revolution: A Historiographical Inquiry*, University of Chicago Press, Chicago, 1994, esp. ch. 5. This is not to say that Marxist thought cannot be informed by complexity Indeed, Urry notes a level of relevance. Urry, 'The Complexities of the Global', pp. 240-3. Moreover, dialectical process are central to appreciating the complexity of societies. The issue is to not succumb to a teleological endpoint.

[20] Hoffmann, *State of War*, pp. 256-9.

[21] Indeed, this level of reductionism and axiomisation is only dwarfed by the determinist and linear progression held by alternative viewpoints that felt, from the 1950s onwards, that a gradual reduction of authoritarianism in the Third World would occur in time. Authoritarian rule, from this historical determinism perspective, was or is still considered to be transitional and the conviction was (or is) that with the gradual increase of wealth and the growth of the middle class would (or will) result in the replacement of authoritarian regimes. Richard Robison, Kevin Hewinson, and Garry Rodan, 'Political Power in Industrialising Capitalist Societies: Theoretical Approaches' in Kevin Hewinson, Richard Robison, and Garry Rodan, eds, *Southeast Asia in the 1990s: Authoritarianism, Democracy and Capitalism*, Allen and Unwin, St Leonards 1993, p. 13. Here the authors, in particular point the finger at Samuel Huntington. For a more recent, and vastly improved, approach see Samir Rihani, 'Complexity Theory: A New Framework for Development in the Offing', *Progress in Development Studies*, vol. 5, no. 1, 2005, pp. 55-61.

[22] Vasquez, 'World Politics Theory', p. 844.

a shared idea of what is to be understood.[23] However, the ordering of knowledge is problematic, as it is fundamentally shaped by culture and preconceived notions of reality.[24] Here, the distinction between normative and explanatory theory begins to deteriorate. This is certainly re-enforced, as Wendt suggests, by the way social theories ask some questions, but ignore others.[25] By way of example, take the creation of hard objective geographical boundaries and how they inform the formulation of questions at the moral and social level. These tangible realities shape how individuals and states respond to people who are considered to be 'them' as opposed to 'us':

> There is nothing in the world of brute facts that requires us to draw a sharp distinction between our concern for the interests of our fellow-citizens and those of strangers there are no 'natural' frontiers, moral or otherwise although once we have drawn such a distinction, we have no difficulty in finding features of the world which legitimate our actions.[26]

This is not to suggest that the non-linear-inspired theories are depicted as breaking ground never before broken. For one, it is widely acknowledged, and from many theoretical perspectives, that '[i]nappropriate images and ill-conceived perceptions of world politics can lead directly to inappropriate or even disastrous

---

[23] And, again, it is vital to recognise (and in relation to economics) that 'To reduce the understanding of human action to the terms of purely physical laws is to ignore those very distinguishing features of humans - speech, reason and spirituality. Interestingly, from a (normative) individualist position, the reduction of human endeavour to the language of physics is an even greater sin - for how can the universal laws of physics help explain the unique individual. The point is not that economics must be a normative discipline but, rather, that economics cannot operate without normative beacons to guide it', Philip, 'Foundation for Evolutionary Economics?', Pradeep Philip, 'Transcendental Realism – A Foundation for Evolutionary Economics', *International Journal of Social Economics*, vol. 22, no. 12, 1995, p. 22. Similarly, yet from a different tack, it should be remembered that theories often do not work in either or both the social or natural worlds, '*the word "reality" refers to the resistance of the world to conform to every imaginable conception humans think up.*' Vasquez, *The Power of Power Politics*, p. 225.

[24] Heinz R. Pagels, *The Dreams of Reason: The Computer and the Rise of Complexity*, Simon and Schuster, New York, 1998, p. 39.

[25] Wendt, 'Anarchy is What States Make of it', p. 391. Take, for example, that for Wendt 'in contrast to Classical Realists who would posit fear, insecurity, or aggression as essential parts of human nature, I am suggesting these feeling are effects of unmet needs and therefore contingent', Wendt, *Social Theory of International Politics*, p. 132.

[26] Chris Brown, 'On the Borders of (International) Political Theory', in O'Sullivan, Noel ed., *Political Theory in Transition*, Routledge, London, 2000., p. 190. Indeed, Edward Said's basic premise was that 'Orientalism was ultimately a political vision of reality whose structure promoted the difference between the familiar (Europe, the West, "us") and the strange (the Orient, the East, "them")' Edward W. Said, *Orientalism*, Penguin Books, London, 1991 [1978], p. 43.

national policies'.[27] Further, this is not to suggest that IR theorists are generally unaware that their respective theories are heuristic and are representations of only an idea of a part of reality, but it is that rationalist models do not reflect a complex reality. It is the endogenous nature of change, and continuity, that must be absorbed by IR theories. Significantly, this is the realisation that the longevity of a set of arrangements should not, in material terms, translate to concepts of 'best practice' or, metaphysically, it should not ontologically privilege a particular worldview. As Jervis, from his realist perspective, states:

> A system could be stable and short-lived if it had the bad luck to be quickly confronted by a large or unusual shock. Conversely, a system could last a long time, not because it was stable, but because it happened to exist during propitious times. But talking of exogenous shocks has some difficulties in international politics since the policies of the states can both challenge the stability of the system.[28]

In introducing a level of appreciation as to how non-linear approaches may affect differing perceptions of what constitutes the world, the interconnectivity and the resultant intersubjectivity present themselves as an excellent starting point. When studying the interconnectedness of social systems, networks have become a popular analogy. Yet, conceptually even something as, presumably, simple as a network is dependent upon the presuppositions that inform this particular depiction of a social reality.

Commencing at a most basic level, it can be said that all individuals live in 'an ocean of networks', whereby every action is part of a greater network. In societal terms this involves family, working and technological networks,[29] yet even with this short list the differing permutations and possibilities are immense. The latter

[27] Keohane and Nye, *Power and Interdependence*, p. 4. See also Jervis, *Perception and Misperception in International Relations*, passim, esp. pp. 19-21 and ch. 8.
[28] Jervis, *System Effects*, p. 97.
[29] D.A. Seeley, 'Network Evolution and the Emergence of Structure' in Bossemaier and Green, Eds., *Complex Systems*, Cambridge University Press, Cambridge, 2000, p. 52. A network is, to put it simply, a collection of connected points called nodes. Edward Rothstein, 'Lacking a Center, Terrorist Networks Are Hard to Find, Let Alone Fight', *New York Times*, October 20, 2001, p. A11.

are a way of imagining how multiple and feedback-driven interactions create ties that bind in some way. For a complexity-informed approach, these relationships underpin systems, as the connectivity is what establishes and reinforces why certain units, agents or groups interact. Moreover, multiple networks interplay and overlap, allowing for sub-systems to emerge and develop:

> Components with especially tight connections form sub-systems, so even homogenous components can support internal diversity through realignment of relationships to create non-identical sub-systems. Economic entities form sub-systems according to their relationships in space, competitive niches, and shared consumer preferences. Ecological entities form sub-systems within species or outside of species …. Any given component can belong to multiple sub-systems. A single person, for instance, can simultaneously be part of a family, union, investment club, and regional economy. A tree is part of a larger community of trees through mechanisms such as seed dispersal and has symbiotic relationships with other plants and animals.[30]

Any analysis of a state-based international system must take such overlapping networks into consideration. This is because, as the state itself emerges from the multiple interactions of various subsets, so too does the international system with the important consideration that these networks often cut across the traditional domestic/international divide. One of the best ways to *begin* the process of developing an appreciation of how connectivity shapes agents and structures is to explore the notion of emergent networks. Representing a multiplicity of formulations, networks are exhibited across a great diversity of structures that require some level of communication or communicative action.[31] Path-dependence, the 'locking in'[32] of points of attraction, are part of what drives far-

[30] Steven M. Manson, 'Simplifying Complexity: a Review of Complexity Theory', *Geoforum*, vol. 32, no. 3, 2001, p. 409. See also Kavalski, 'Emergence of Complex International Relations Theory', p. 438.
[31] See Jürgen Habermas, *The Theory of Communicative Action: Reason and the Rationalization of Society*, vol. 1, trans. Thomas McCarthy, Beacon Press, Boston, 1984, pp. 94-101.
[32] This refers to the idea of increasing returns, a form of positive feedback, see Arthur, 'Positive Feedbacks in the Economy', p. 81. Radically, It has been suggested, perhaps bordering on the extreme that the process of increasing returns could conceivably, over the *long duree* undermine the competitive nature of Western world's capitalist economies. Sardar and Abrams, *Introducing Chaos*, pp. 116-7.

from-equilibrium processes. This, in turn, signifies that a natural equilibrium or resting place is *never* attainable.

Complex networks support concepts of globalisation.[33] Yet again, theories that are informed by a complexity paradigm can draw significant conclusions. For example, trying to control or design such networks is difficult in itself, but to remove one, as is the focus on what was termed by the Bush administration as the War on Terror, can prove equally, if not more, difficult.[34] More generally, it is possible to recognise that multiple open networks contribute to, enrich and generally add to the complex composites of societies, ideas or cultures. It is 'intersocietal systems'[35] that challenge rationalist models of international relations. These complex composites are points of attraction that interact, contribute to, resist, and generally form and inform the processes of globalisation. For instance, basic arguments of greater economic integration as a means to explain the phenomenon of globalisation[36] ignore the breadth and depth of not only the existence, but also the consequences, of the increased connectivity of multiple worlds. Theories that incorporate an appreciation of emergence can counter arguments that globalisation is merely the extension of capitalism, either from the

[33] Furthermore, the concepts of thick and thin globalisation as put forward by Keohane and Nye tie in well with the premise being put forward (as do the concepts of soft and hard power). Furthermore they have noted the links between complex modes of thoughts, highlighting the unpredictability of the global system due to the sensitivity of initial conditions (as will be discussed at a later stage); Keohane and Joseph S. Nye Jr., 'Globalization' pp 108-113. For greater detail see their book *Power and Interdependence*, 3rd ed., Longman, New York, 2001, ch. 10. On earlier work in the field of IR that notes sensitivity to initial conditions see also Gaddis, 'International Relations Theory and the End of the Cold War', pp. 28-9.

[34] The resilience of Al Qaeda, with its flattened, essentially non-hierarchical structure, has proved difficult to remove and illustrates the ineffectiveness of current linear orthodoxies and the associated attempts to subdue asymmetric non-state threats in an 'ocean of networks'. See Ronald J. Deibert and Janice Gross Stein, 'Hacking Networks of Terror', *Dialogue IO*, vol. 1, no. 1, 2002, pp. 1-14; John Arquilla and David F. Ronfeldt, 'The Advent of Netwar (Revisited)'in John Arquilla and David F. Ronfeldt, eds, *Networks and Netwars: The Future of Terror, Crime, and Militancy*, Rand, Santa Monica, 2001, pp. 1-22; Michele Zanini and Sean J.A. Edwards, 'The Networking of Terror in the Information Age' in ibid., pp. 30-33; Arquilla and Ronfeldt, in ibid., 'What Next for Networks and Netwars?', pp. 326-7; John Arquilla and David F. Ronfeldt, 'Netwar Revisited: The Fight for the Future Continues', *Low Intensity Conflict and Law Enforcement*, vol. 11, no. 2 & 3, 2002, pp. 178-89; Rothstein, 'Lacking a Center, Terrorist Networks Are Hard to Find, Let Alone Fight', p. A11. 'Oceans of networks' from [34] Seeley, 'Network Evolution and the Emergence of Structure', p. 52.

[35] Stewart, 'Complexity Theories, Social Theories', p. 333.

[36] That is, of course, accepting globalisation as a phenomenon as opposed to an epiphenomenon. For example historical materialists consider it to be secondary and a 'consequence of an inherent expansionary logic of capitalist societies', meaning that it 'has no independent causal powers'. David Held and Anthony McGrew, *Globalization/Anti-Globalization: Beyond the Great Divide*, 2nd ed., Polity Press, Cambridge, 2007, p. 7.

historical materialist or neo-liberal perspective. Capitalist intent may well have driven the system in a particular direction, but globalisation emerges from the context, like a modern-day Frankenstein, replete with the unpredictability of the creature.[37] The existence of phenomena that define and presuppose complex systems, from complex feedback processes through to ones involving self-organisation, means it becomes much more than any capitalist logic could imagine, and results in, or creates the possibility for, a multiplicity of unexpected outcomes. For example, take the sentiment that:

> Migration is globalisation from below. If the 'overdeveloped' world refuses to trade with the underdeveloped world on fair terms, to forgive debt, to extend loans, to lift trade barriers against food and basic manufactured goods, then there can only be an increase in the flow of people … The most telling human critique of globalisation is not the black-clad protestors in Seattle or Genoa, it is the still, silent bodies of the illegals, in ships, trucks or car boots, passing through the borders.[38]

To this end, globalisation can be understood, theoretically, as an emergent process that allows the structure of a system to remain whilst it evolves and adapts. What cannot be held for certain is what it may evolve or adapt into. This notion of structure, as is dealt with later in the chapter, is fluid and is shaped by the principles of self-organisation. The process of bifurcation, linked to sensitivity to initial conditions, has led to claims that 'even a few influential individuals can determine a society's direction by triggering a revolution'.[39] Through self-organisation, systems inherently increase in complexity, with concepts like memory in social systems playing a central role by underscoring how history informs the decision-making of agents.[40] Furthermore, a self-organising system

---

[37] Victor Frankenstein's creature, it should be remembered, need not be necessarily viewed as an evil. Indeed, his creation was born of youthful exuberance, inquisitiveness and the possibilities of science. The creature's demise (and Victor's) was one of misunderstanding and neglect. See Mary Wollstonecraft Shelley, *Frankenstein: or, The Modern Prometheus*, ed., M. K. Joseph, Oxford University Press, New York, 1980.

[38] McKenzie Wark, ''Preface' to Anthony Burke, *In Fear of Security: Australia's Invasion Anxiety*,: Pluto Press, Annandale, 2001, p. xviii.

[39] Eidelson, 'Complex Adaptive Systems in the Behavioral and Social Sciences', p. 51.

[40] For a good overview of decision making, trust and cooperation in complex systems see Axelrod, *The Complexity of Cooperation.*

cannot be driven to a specific end and, for many of the reasons already mentioned, are difficult to reduce.[41] Within social settings, self-organisation is evident by the manner in which norms, power relations and notions of authority shift and transform over time. Indeed, new organisations, forms of authority and differing power relations will constantly emerge through a non-additive process.[42] Illegal migration flows and the plight of refugees are easily constructed as examples of such an emergent phenomenon. In short, the space in which the international system is theorised allows for an array of possibilities, and does so despite the efforts of linear theory construction. Yet dealing with the concept of space is not without difficulties; networks do not exist as such, they are imagined and the spaces in which they are imagined are ontologically determined.

When theorising, and, indeed, when speaking of reality, it is common to speak of space. In doing so, space often becomes place, and with it the certainty that is afforded to the physical world. Yet, space is an invisible and intangible notion through which we construct, within our minds, an understanding of human society. It is 'where the plans, ambitions, and actions of individuals and groups incessantly jar against each other – colliding, blocking, coalescing, separating'.[43] Assumptions and prejudices from a world enthralled by neat linear orderliness exist and are supported by dominant paradigms within such a space. This allows for simple trajectories, structures and systems to be built from reductionist axioms, so that the world in all its complexity may to be understood. Again, structural theories of international relations certainly fit into this category, as they boil down the world of innumerable variables to a small number of principle fundamentals[44] that, effectively, become inductively assumed *a priori*

[41] Cilliers, *Complexity and Postmodernism*, pp. 92-3.
[42] Hoffman and Johnson, 'Change and Process in a Complex World', p. 3. There mere fact that higher level structures evolve is an example of emergence. R. Keith Sawyer, 'Simulating Emergence and Downward Causation in Small Groups', in S. Moss and P. Davidsson, eds., *Multi-Agent-Based Simulation*, Springer Berlin, Heidelberg, 2000, p. 58. See also Sawyer, 'The Emergence of Creativity', pp. 455-6.
[43] Sheldon Wolin quoted in Yale H. Ferguson and Richard W. Mansbach, *Remapping Global Politics: History's Revenge and Future Shock*, Cambridge University Press, Cambridge, 2004, p. 74.
[44] Reducing both down (say, to axiomatic principles or individuals) and reducing 'up' (to simplified corporate entities like the state).

unobservable structures.[45] Indeed, as Gaddis argues: 'it is very likely that such structures exist in our minds, producing observable effects in the way in which we perceive reality, respond to it, and even, by means of language, characterize it'.[46] Fukuyama, for example, points out that:

> while man's very perception of the material world is shaped by his historical consciousness of it, the material world can clearly affect in return the viability of a particular state of consciousness. In particular, the spectacular abundance of advanced liberal economies and the infinitely diverse consumer cultures made possible by them seem to both foster and preserve liberalism in the political sphere.[47]

The truthfulness of this claim lies both in the material and the ideational realm. It uncovers elements that represent the international system, and the interplay between the material and the imagined. Within a theoretical space, it can be qualitatively expressed as an attractor, and a Western attractor at that.[48] It is dominant, it is robust and it is driving many elements of the world economy and of the world system at this time. However, the linear teleological assumptions are not supported by this conceptualisation (being 'stuck in history'[49] infers a subservience to the Newtonian paradigm). For instance, acknowledging non-linear and emergent possibilities within a less contained idea of theoretical space

---

[45] See Gaddis, 'International Relations Theory', p. 14. And here implicitly accepting the dominant nineteenth century economic ontology that hailed from the Newtonian paradigm that was discussed in chapters one and four.

[46] ibid., p. 15.

[47] Francis Fukuyama, 'The End of History', The National Interest, 1989, p. 9. It is worth pointing out, as some scholars have, that the 'idea… that American power might be encouraging an inexplorable, global convergence around western values, political practices and patterns of production and consumption looks increasingly like wishful thinking, liberal complacency, and a product of a failure to recognise the implications that flow from massive international inequalities of wealth and power. American hegemony is – rightly or wrongly – seen as responsible for a global order that entrenches the interests of a privileged western elite whilst condemning a third of humanity to poverty', Beeson and Bellamy, 'Globalisation, Security and International Order', p. 339.

[48] For instance, resurgent Indian political thought offers alternatives, whether it be the particular cosmopolitanism of Ghandi or the possibility of a federated world state, accepting of unity and diversity, of Hindutva conception of political space. Bajpai, Kanti, 'Indian Conceptions of Order and Justice: Nehruvian, Gandhian and Hindutva, and Neo-Liberal', in Foot, Rosemary; Gaddis, John Lewis, and Hurrell, Andrew, eds, *Order and Justice in International Relations*, Oxford University Press, Oxford, 2003, pp. 250-3.

[49] Francis Fukuyama, 'The End of History', *The National Interest*, vol. 16, 1989, p. 18.

allows for concepts like scaling, which, in turn, reinforce an acceptance of nested ontologies. [50]

At play are multi-dimensional and overlapping worlds. However, accounting for this theoretically is difficult. The previous chapter illustrated how realism, and neo-realism in particular, stripped back and reduced the world to the interaction of a-historical and self-similar states. It was argued that this mono-causal logic did not appropriately capture what was 'out there', yet to merely replace it with a 'multi-causal' theoretical approach would not be sufficient as 'to talk of the world in terms of multi-causality is to talk solely of an empirical world.'[51] As David Harvey quite correctly points out: the 'world is composed of a complex array of material entities and causal processes which are not immediately available to everyday experience'.[52] How the international system is thought to work materially is as much influenced by the analogies that communities use to describe the world.[53] This is the intersection between theory, practice, explanation and interpretation. Moreover, it is the dominant paradigm that assumes the responsibility of delivering socially constructed forms of knowledge. This extends to symbols and equations, through to the methodological frameworks and the use

---

[50] In reference to ontological layering and 'hierarchical entities' Harvey and Reed, in their very strict formulation provide the example 'of a worker wiring a computer board takes place at several hierarchical levels simultaneously. He or she is engaged in: 1) a technical act of production; 2) an economic act designed to yield profit for another; 3) a practical act of normative conformity (or deviance, as the case may be) vis-à-vis the culture of the work place; 4) providing for his or her family; 5) an historical act with definite antecedents that will produce future outcomes, etc.', Harvey and Reed, 'The Evolution of Dissipative Social Systems', p. 382.

[51] Philip, 'Foundation for Evolutionary Economics?', p. 24. This is also representative of the general issue associated with the idea, that runs counter to complexity theory and is abound in the study of economics that 'the traditional view of relation between laws and consequences – between cause and effect – holds that simple rules imply simple behaviour; therefore complicated behaviour must arise from complex rules', Zhang, 'Complex Systems and Economic Dynamics' p. 84.

[52] David L. Harvey, 'Agency and Community: A Critical Realist Paradigm', *Journal for the Theory of Social Behaviour*, vol. 32, no. 2, 2002, p. 165.

[53] Of course, the complex dialectic continues with the material world helping to create those analogies and so on and so forth. Chris Brown notes as much when he highlights the difficulty in defining international relations as it does 'not have some kind of essential existence in the real world of the sort that could define an academic discipline. Instead there is a continual interplay between the 'real world' and the world of knowledge. The latter is, of course, shaped by the former, but this is not simply a one way relationship.' Chris Brown (with Kirsten Ailey), *Understanding International Relations*, 3rd ed., Palgrave Macmillan, New York, 2005, p. 1. Again, one could also consult Habermas. See Habermas, *The Theory of Communicative Action*, pp. 94-101.

of language, which all, to some degree, contribute to the development of an accepted impression or impressions of reality.

Critical realism offers an entry-point for the absorption of complexity, not least because it is sympathetic to attempts to 'unconceal' reality.[54] Critical realism, which exists in opposition to empirical realism,[55] is situated, ontologically, over any level of empirical knowledge. The theory is premised on the existence of an 'actual' reality, yet complete or universal knowledge of this domain is unattainable via human experience. Consequently, the approach is critical of theories which reductively produce an 'actualism' as empirical fact.[56] There exists only a transcendental reality, and revealing reality becomes a *social* process.[57] In proposing critical realism as a means 'to reclaim reality', Patomäki and Wight press that there exist 'different ontological layers in the world, and the social world is itself a causally efficacious emergent level'.[58] Moreover, there are 'levels and depth *within social worlds*' that attribute significance to theory-construction.[59] The idea that a 'series of nested, ontological phenomena that are cumulative in nature and fundamentally irreducible'[60] represents a starting point for the transference of such ideas to the study of complex systems. This is a reflection of a far wider movement in the social sciences, where an appreciation of the fuzziness and indeterminacy of borders between systems has developed considerably. With the exception of ecological studies, the social sciences are required to deal far more

[54] This is because any critical realist perspectives will, of course, be bound by its presuppositions. Jackson, 'Naturalism in Economics', p. 777.
[55] Roy Bhaskar, 'Philosophy and Scientific Realism' in Margaret Archer, Roy Bhaskar, Andrew Collier, Tony Lawson and Alan Norrie, eds, *Critical Realism: Essential Readings*, Routledge, London, 1998, pp. 19-20.
[56] Roy Bhaskar and Tony Lawson, 'Introduction: Basic Texts and Developments' in ibid., pp. 5-6
[57] ibid. 'The name "critical realism" is not of Bhaskar's making. It is an elision of two terms that are pivotal to understanding his contribution to the philosophy of the social sciences: "*transcendental realism*" and "*critical naturalism*." Transcendental realism forms the basis of Bhaskar's philosophical ontology and refers to the argument he uses in developing his realist conception of science. Critical naturalism, by contrast, bears directly on the methodological question of whether or not a genuine natural science of society is possible', Harvey, 'Agency and Community', p. 164. See also Gunnell, 'Realizing Theory', pp. 933-5.
[58] Patomäki and Wight, 'After Postpositivism?', p. 235.
[59] ibid., p. 232. This process should be underwritten by the presuppositions outlined in Chapter Three.
[60] Harvey and Reed, 'The Evolution of Dissipative Social Systems', p. 374. Harvey and Reed's notion of the 'nested ontology of dissipative social themes', which attempts to step beyond the structural functionalism of Talcott Parsons, presents a hierarchical yet cumulative and layered, reality that privileges social systems. ibid., p. 373. The anthropomorphism is most prevalent in their ninth proposition which declares that 'social systems are a special class of naturally constituted dissipative systems' ibid., p. 389.

regularly than the hard sciences with 'ensembles of systems'.[61] In dealing with multiple social phenomena, that is, different 'comparable cases', Byrne argues that:

> The essence of the case in a complex frame is that cases are in themselves complex systems which are nested in, have nested within them, and intersect with other complex systems. So, for example, a city household is nested within global and national systems and has nested within its neighbourhoods, households and individuals. Nesting is not hierarchy. Determination runs in all possible directions, not just top down. All these levels potentially have implications for all other levels.[62]

In a material sense, this is not altogether difficult to comprehend, but once theorising begins, the ability to attribute ontological significance as to what is there or what is most important runs the risk of incommensurability. However, this Kuhnian prison is the domain of the 'mature sciences', and is why any paradigm shift, in the strictest sense of the expression, can occur *only* at the meta-theoretical level. Patomäki and Wight quite rightly claim that 'if there is no ontological overlap then there is little point in trying to compare theories, or bemoaning the fact that we can't.'[63] Comparison between worlds, with incommensurability pushed to one-side, is possible. Patomäki and Wight are then able to argue that:

> Ontologically the social world is composed of a fragmented interplay of practices based on various partial, relational perspectives, and a more comprehensive perspective is achieved by transcending and adapting these partial perspectives and synthesising them into a broader, non-reductive perspective capable of incorporating the strengths of all. Note, however, that this does not imply the destruction of competing perspectives. The synthesis we advocate does not imply a grand theory of everything. … What is important to realize is that this process is continual. No synthesis can ever be absolute and final: reality is constantly changing, and so there can only be a 'dynamic' synthesis that is constantly being reformulated.[64]

[61] Byrne, 'Complexity, Configuration and Cases', p. 101.
[62] ibid., p. 105
[63] Patomäki and Wight, 'After Postpositivism?', p. 226
[64] ibid. p. 227.

Similarly, the acceptance of non-linear science at the meta-theoretical level assists with the move away from reductionism, and it most certainly should not be seen as an offer for a 'grand theory of everything'.[65] Quite simply, theory-making is influenced and shaped by its presuppositions.

Before many others attempted to come to terms with the limitations of traditional IR theory, Rosenau indicated an early underlying appreciation for how theory might be informed by this new paradigm. His *Turbulence in World Politics*, published just as the Cold War was nearing its end, argued that like a complex adaptive system, the boundaries that constrain the actions of all agents within the international system *do* exist. Yet, there should remain a wariness towards those 'metatheoretical premises that locate causations exclusively in either micro or macro sources'.[66] He also looked for 'multilevel theorizing', which, at one level, can be articulated in the form of the continued divide between the domestic and international, which for so long was maintained by mainstream theories.[67] With vision, he also argued that issues can 'cascade across and through all systems [and subsystems] via diverse roots and with varying intensities'.[68] Returned by Rosenau was 'the relationship among parts and wholes while taking account of multiple and continuously shifting identities and loyalties.'[69] Nested, overlapping and multiple worlds are a regularity in Rosenau's universe.[70] The challenge now is to reconcile the alternative paradigmatic influence more generally to how theory construction occurs with in International Relations.

65 ibid.
66 Rosenau, *Turbulence in World Politics*, p. 150.
67 ibid., pp. 42, 44.
68 ibid., p. 42. What Rosenau refers to as cascading 'subgroupism'. ibid., passim.
69 Yale H. Ferguson and Richard W. Mansbach, 'Global Politics at the Turn of the Millennium: Changing Bases of "Us" and "Them"', *International Studies Review*, vol. 1, no. 2, 1999, p. 85.
70 Of course, it is not difficult to suggest that one is, indeed, dealing with a *multi*verse as opposed to the grand narrative of the singularity of a *uni*verse.

In this respect, it is important not to forget that the reflectivist positions, existing in opposition, have meaningfully contributed to debates of this nature. [71] For example, suggestions that subject and object are constituted by each other 'through recurrent practices',[72] a mainstay of post-structuralism, share similarities with feedback-driven emergent process. However, more radical interpretations cannot hold sway, as 'visions of any future have to proceed from the awareness of some kind of past; otherwise there can be no conceptual frame of reference – more than that, there can be no language – with which to express them.'[73] Byrne is convincing in his reasoning as to why complexity theory should not be misconstrued as a post-modern science. He states that:

> Despite assertions that complexity theory represents a foundation for postmodern science, the complexity project necessarily confronts the subjective relativism of postmodernism with an assertion that explanation is possible, but only explanation that is local in time and place. Complexity science addresses issues of causation with cause, necessarily, understood as complex and contingent. The project of establishing how things have come to be as they are is valid in the complexity frame of reference.[74]

This again does not sit too far from Rosenau, whose ideas embrace explanation, but neither float into the realms of unhelpful reflectivism, nor adhere to dominant linear perspectives. His work accepts the nested and contextually constituted nature of things. He argues, for example, that there are many contradictory forces

[71] Vasquez well captures the contribution of post-modernism when he writes: 'Post-modernism denies the Enlightenment on two grounds. First it denies the idea of progress, and in its stead, it places the ideas of discontinuities. This is one of Foucault's (1972) major insights. History is not moving forward or backward. It lacks teleology, as well as evolution. Second, post-modernism not only denies the idea of progress, but rejects that the purported end of the Enlightenment, the Modern, is the end of history, the perfection of humanity, or even doing a worthwhile goal. For the post-modernist, there is no optimal way of doing things. There are many ways, and one is not necessarily better than the other. Likewise, there is no one Truth (with either a capital T or small t) but many truths. Post-modernism rips off capitalism's mask of science and denies the claims of modern economics that there is but one way to solve the problem of food and shelter and that other forms of organizing economies will be less efficient or beneficial, if they "work" at all. At the same time, it denies Marxist claims that certain modes of production are appropriate to certain conditions of history. For the post-modernist, "nothing is written."' Vasquez, *The Power of Power Politics*, p. 216.

[72] Torbjørn L. Knutsen, A *History of International Relations Theory*, 2nd ed., Manchester University Press, Manchester and New York, 1997, p. 280. This, of course, lends itself to constructivist thought.

[73] Gaddis, 'International Relations Theory', p. 6.

[74] Byrne, 'Complexity, Configuration and Cases', pp. 97-8.

at play across differing aggregate levels. Strong interrelationships can form within and between his nominated levels, whilst paradoxically encouraging both centralising and decentralising tendencies.[75] Yet he positions himself away from radical reflectivists, evoking the ideas inherent in complexity, that 'the empirical and normative enterprises need each other.'[76] Constructivism also does not sit too far from this nexus. Dealing with culture, Wendt is quick to argue that culture arises via the '*mutually* constituted and co-determined' relationship between agency and structure.[77] Culture becomes a *'self-fulfilling prophecy'*,[78] drawing similarities with the 'locking in effect' of positive feedback. Wendt also highlights five overlapping areas of consternation in respect to identifying culture. His point of view can be linked to an articulation of culture as being nested in a complex and feedback-driven set of multiple arrangements. He writes:

> One is internal contradictions between different logics within a culture. Culture consists of many different norms, rules, and institutions and the practices they induce will often be contradictory. A second is the fact that agents are never perfectly socialized, such that they only have shared beliefs. Every one of us has private beliefs that motivate us to pursue personal projects that can change our environments. The unintended consequences of shared beliefs are a third source of conflict. A tragedy of the commons can be rooted in a shared understanding as a commons, but produce an outcome that eventually causes a change of belief. Exogenous shocks are a fourth factor. A revolution, cultural imperialism, or an invasion by conquistadors can all transform cultural order. And finally there is creativity, the invention of new ideas from within a culture[79]

---

75 Rosenau, *Distant Proximities*, Ch. 3, esp. pp. 70-7.

76 ibid., p. 208.

77 Rosenau, at one level attempts a similar position with his attempt to 'treat micro and macro phenomena as interactive …', Rosenau, *Turbulence in World Politics*, pp. 143-4. However, Rosenau does present a less than adequate appreciation for the structurationist position (and the manner in which rational choice is predominately employed in the study of international relations). ibid., pp 147-8.

78 Wendt, *Social Theory of International Politics*, pp. 184, 186. Certainly a Freudian perspective can be added in that 'the two process, that of the cultural development of the group and that of the cultural development of the individual are, as it were, always interlocked. For that reason some of the manifestations of the superego can be more easily detected in its behaviour in the cultural community than in the separate individual', Sigmund Freud, *Civilizations and its Discontents*, trans. and ed. James Strachey, W.W. Norton and Company, New York, 1962, p. 144.

79 Wendt, *Social Theory of International Politics*, p. 188.

Constructivists use discourse and, more generally, the importance of history and culture to identify 'beliefs and interests, and establishes accepted norm of behavior'.[80] Ideas, then, help inform what it is to be studied. Constructivists like Wendt use this method exclusively to explain the behaviour of states. Similarly, in building their theory of Regional Security Complexes, Buzan and Wæver, who attempt to merge constructivist and materialist accounts of the international, also maintain that the state is the central and *ultimate* unit of analysis.[81] In a nested and overlapping world, the dominance of a particular aggregate cannot be ignored. Therefore, from this perspective, the state can be appreciated as an ongoing point of attraction. The next section shows how it has been imagined, and then argues how it could be imagined.

Aggregating Society: Acknowledging the State

The most enduring political unit when analysing international relations is the state. Yet, its ability to endure is not because of its rigidity as a notion, but a result of it being an amorphous concept. Take J. P. Nettl's affirmation that the state is a conceptual variable which may be considered, utilised and appropriated for use, depending on the context and the disciplinary and theoretical positioning of particular scholars. It is a malleable, yet often useful, construct.[82] This means that how it is imagined both contributes to its significance and the manner in which it

[80] Walt, 'One World, Many Theories', p. 41. Moreover, 'In social (and IR) theory it has been commonplace to describe action as culturally or discursively structured, but rarely is a mechanism supplied through which this effect might actually work. Wendt, *Social Theory of International Politics*, p. 134. Walt also notes that constructivism 'largely replaced Marxism as the preeminent radical perspective on international affairs.' Walt, 'One World, Many Theories', p. 41.

[81] Barry Buzan and Ole Wæver, *Regions and Powers: The Structure of International Security*, Cambridge University Press, Cambridge, 2003, p. 4, passim. The regional perspective upon which they base their approach at the very least, by their own admissions, undermines Huntington's United States centric civilizational argument by favouring the emergence of [*a la* Rosenau] 'sub-systems' at regional level as opposed to the cultural fault lines at the macro-level proposed by Huntington. ibid, p. 41. Further, they contend that the bias that saw the preferencing the 'global over the regional' contributed to 'many of the disasters of Cold War policy from Southeast Asia and the Middles East, to Southern Africa and South Asia.' ibid.

[82] Nettl, 'The State as a Conceptual Variable', pp 559-592. Of course, alternatives have always existed and, in some capacity, continue to do so: 'They can be more easily invoked than historical structures that have become obsolescent, such as the tributary state model which has been mostly forgotten even in East Asia (although the Chinese treatment of Hong Kong can be seen as a manifestation of traditional Sinocentric practices)', Krasner, 'Rethinking the Sovereign State Model', p. 41.

interacts (or is thought to interact). For rationalist theories of international relations Krasner rightly points out that:

> The sovereign state model is a basic concept for the major theoretical approaches to international relations, including neorealism and neoliberal institutionalism, for both of which it is an analytic assumption, as well as international society perspectives, for which it is a constitutive norm. For neorealism, the ontological givens in the international system are Westphalian sovereign states, understood as unitary rational actors operating in an anarchic setting and striving to enhance their wellbeing and security. These states are constrained only by the external environment, that is, by the power of other states. Realism does not suppose that all states can guarantee their autonomy. If, however, a state loses its autonomy—if, for instance, its political structures and personnel are chosen by others—then neorealism has nothing to say about how such penetrated states which do not have Vattelian sovereignty might act.[83]

As an example, Jervis underscores the a-historicism and rational egotism of states with his argument that if two states are treated 'as outcasts', then it 'is likely to push them together even if they share no other interest'. To support his argument he uses the example of Germany and the USSR, which signed the Treaty of Rapallo in 1922.[84] Yet examples will always be contingent, and this one only works for the first iteration: the attempted domination of the former over the latter and the consequent assisted destruction of latter by the former in subsequent iterations is related to dynamics far more complex than merely both being outcasts. Moreover, an 'outcast' is, to begin with, a form of identity in itself. Waltz, with his scientific and economically-inspired neorealism, removes all doubt with respect to the nature of states assuming 'that the process determining the fundamental identity of states are exogenous to the states' environments, global or

---

[83] Krasner, 'Rethinking the Sovereign State Model', pp. 21-2. 'Vattelian sovereignty refers to the exclusion of external sources of authority both de juri and de facto.' Basically it is the principle of non-intervention. ibid., p. 20.

[84] Jervis, *System Effects*, p. 223.

domestic'.[85] As an aside, Jervis merely acknowledges, somewhat deferentially, that the difficulty in classifying 'some independent variables', like beliefs and norms, as a 'complication'.[86]

The English School's and constructivists' theories allow for a more generous idea of state interactions, guided by norms of behaviour that arise endogenously and exogenously. As was emphasised in the previous chapter, '"international society" has a basis in reality that is sometimes precarious but has at no stage disappeared'.[87] Bull, for example, highlights that the erosion of traditional diplomacy has occurred as state leaders have had to increasingly consider the sentiments of society at large when formulating and conducting foreign policy.[88] The flow-on effect is the evolution of international norms that further constrain decision-making elites.[89] Indeed, in large part because of these processes, warfare is now less often considered to be a 'virtuous exercise of state power', according to nineteenth century ideals. Instead, it is seen as being 'at best, a necessary evil'.[90] Here, constitutive theory-making helps to reappraise how norms and ideas are shaped (and vice versa), and how they are shaped by the interactions of this society of states. The importance of identity and the interconnections between states emerges from this theoretical perspective. Krasner again captures the chief sentiments:

> The sovereign state model is also a core concept for international society approaches, most notably the English School and various constructivist approaches. Here the sovereign state model is understood as a constitutive norm which generates actors and defines their competencies. All participants in international society—public officials, diplomats, statesmen, political leaders—

[85] Ronald L. Jepperson, Alexander Wendt, and Peter J. Katzenstein, 'Norms, Identity, and Culture in National Security', in Peter J. Katzenstein, ed., *The Culture of National Security: Norms and Identity in World Politics*, Columbia University Press, New York, 1996, p. 41.
[86] Jervis, *System Effects*, p. 92.
[87] Bull, *The Anarchical Society*, p. 40.
[88] ibid., p. 169. See also Kennedy, *Rise and Fall of Great Powers*, p. 366.
[89] Checkel, 'International Norms and Domestic Politics', p. 477. Further, 'Norm empowerment occurs as agents are taught new values and interests; their behaviour comes to be governed by logics of appropriateness that are learned, through a process of interaction, from global norms. This is the mutual constitution that lies at the heart of the constructivist method', ibid.
[90] Jepperson, et al., 'Norms, Identity, and Culture in National Security', p. 36.

> hold the same fundamental views about the nature of the system, the actors, and how they can behave. Modern international society is composed of territorial units within which public institutions exercise exclusive authority. Actions follow particular patterns not because they are dictated by some higher authority, or coerced by the threat of force, or constrained by the power of other states, but because players have a shared intersubjective understanding. The role of sovereign states permits some kinds of activities but not others.[91]

The state, according to this account, remains the primary political unit within International Relations, with it continuing to be defined by its legitimate monopoly of violence over a given population within a defined territorial area. It therefore remains the supreme sovereign authority.[92] However, in more recent times attacks on the state by processes like globalisation, regionalisation and integration into international regulatory frameworks has led to either doomsday suggestions of the demise or erosion of the state to, less contentiously, an acknowledgment of the relative, as opposed to an absolute, idea of sovereignty.[93] Similarly, with his defence of state sovereignty, Krasner implicitly surrenders to a relative idea of sovereignty when he concludes that '[s]overeignty's resilience is, if nothing else, a reflection of its tolerance for alternatives'.[94] Others claim that sovereignty does little else than create the impressions 'that states are

[91] Krasner, 'Rethinking the Sovereign State Model', p. 22.
[92] On first reading take the definition of the state from the first, fourth, sixth, seventh and eighth articles of the Montevideo Convention on the Rights and Duties of States that 'The state as a person of international law should possess the following qualifications: (a) a permanent population; (b) a defined territory; (c) government; and (d) capacity to enter into relations with the other states.'(Article 1). On the equality of states take that 'States are juridically equal, enjoy the same rights, and have equal capacity in their exercise. The rights of each one do not depend upon the power which it possesses to assure its exercise, but upon the simple fact of its existence as a person under international law.' (Article 4) And on recognition and non-intervention that: 'The recognition of a state merely signifies that the state which recognizes it accepts the personality of the other with all the rights and duties determined by international law. Recognition is unconditional and irrevocable.' (Article 6); 'The recognition of a state may be express or tacit. The latter results from any act which implies the intention of recognizing the new state.' (Article 7) and ; 'No state has the right to intervene in the internal or external affairs of another' (Article 8). Montevideo Convention on the Rights and Duties of States, Dec . 26, 1933, 49 Stat . 3097, T .S . 881, Arts . 1, 6, 7 & 8.
[93] For example see Philpot, 'Sovereignty: An Introduction and Brief History', pp. 353-368; Roland Axtmann, 'The State of the State: The Model of the Modern State and Its Contemporary Transformation', *International Political Science Review*, vol. 25, no. 3, 2004, pp. 259-279.
[94] Stephen D. Krasner, 'Abiding Sovereignty', *International Political Science Review / Revue internationale de science politique*, vol.22, no. 3, Transformation of International Relations: Between Change and Continuity / Transformations des relations internationales: entre rupture et continuité, 2001, p. 248. Throughout he argues that the challenges and difficulties have always challenged the sovereignty of states (and, indeed, there are newly developing challenges). Control, that is, power, still rests with states. ibid., passim.

homologous, disguising the more important fact that actual states have little in common except legal sovereignty'.[95] The argument that places the state as a variable concept would therefore appear to be in the ascendancy.

Still further, and with very much a 'common-sense' view of what encapsulates 'post-modern', Buzan and Wæver present an image of a new state whose concerns have shifted, like an individual whose basic needs and fears have been ameliorated, to a point that 'traditional' concerns barely register, and this allows for more thoughtful conjecture. Buzan and Wæver claim that:

> Postmodern states are a relatively new phenomenon, mainly concentrated in the capitalist core. All are within the strong state end of the spectrum,[96] and none are much driven by traditional military security concerns about armed invasion or massive bombardment. These states have moved on from the Westphalian model. They still retain the trappings of modernity, such as borders, sovereignty, and national identity, but for a wide range of things, especially economic and cultural transactions, do not take them nearly as seriously as before. Postmodern states have a much more open and tolerant attitude towards cultural, economic, and political interaction, and have by and large convinced themselves that opening their economies, and to a lesser extent their societies and politics, to a wide range of interactions is good for both their prosperity and security. Necessarily, therefore, they have desecuritised much of the traditional agenda of threats. But at the same time they have acquired a new security agenda, which often focuses on concerns about identity and migration … and about the stability of global economic and environmental systems.[97]

In this respect, domestic political structures can be said to have maintained a high degree of their flexibility and adaptability throughout the twentieth century. This has been able to occur because harder and inflexible notions of the state[98] have given way to fluid and flexible reinterpretations as to what the state represents. Sovereignty can then be seen as weakening, but still remaining an integral part of

[95] Ferguson and Mansbach, 'Global Politics at the Turn of the Millennium', p. 91.
[96] Here they draw on Robert H. Jackson's work on 'empirical sovereignty'.
[97] Buzan and Wæver, *Regions and Powers*, p. 23. For an alternative account of how contemporary international politics can be imagined see Hurrell, *On Global Order*, esp. ch. 10. The chapter considers how a new sense of regionalism will offer 'containers' through which international relations can be understood.
[98] Geyer, 'Future of Scandinavian Exceptionalism', p. 564.

the system.[99] The impact of international money markets and multinational corporations is an often-quoted example of the erosion of state sovereignty, yet it should be remembered that such institutions require strong states in which to invest. Without the state they could not exist and are hence dependent upon it for their own survival.[100] Paradoxes abound in attempting to define the state in a period of greater interconnectivity across multiple dimensions. For instance, borders are becoming increasingly porous, but territory, and its defence, is still a fundamental property of the state. Such contradictions are occurring in a system that represents many different 'scapes': ethnicity, ideology, religion, technology, and popular culture, to name but a few.[101]

Thus, multiple frictions can be seen to be emerging at an ever-increasing rate, yet constants somehow remain. Buzan and Wæver throughout their account continue to privilege territory with some material considerations such as military over economic. They regard some states as being more 'territorialized' than others.[102] Of course, the geographical recognition of the structural boundaries of the state is arguably one of the most central and oldest prerequisites for forming a political community. Yet it may be argued that in the social sciences that deal with the geography of what is 'real', there has been insufficient consideration to accommodate historical change and occurrences that not only challenge traditional divisions of social and political groupings, but also how they might also challenge the actual structures or 'containers' that are used to define occupied geographical space.[103] Just as we cannot consider the earth to be an elementary particle,[104] nor

[99] Rosenau., 'Many Damn Things Simultaneously' pp. 75-76.
[100] Peter Evans, 'The Eclipse of the State? Reflections on Stateness in an Era of Globalisation', *World Politics*, vol. 50, no. 1, 1997, pp. 67-68.
[101] Rosenau, 'Many Damn Things Simultaneously' p. 76. As discussed in Chapter Two. For a more radical argument of globalisation creating a 'borderless world' and of the demise of the nation-state see Kenichi Ohmae, *The Borderless World: Power and Strategy in the Interlinked Economy*, HarperPerennial, New York, 1991 [1990]; Kenichi Ohmae, *The End of the Nation State: The Rise of Regional Economies*, HarperCollins, London, 1995.
[102] Buzan and Wæver , p.12.
[103] John Agnew quoted in Neil Brenner 'Beyond state-centrism? Space, Territoriality, and Geographical Scale in Globalization Studies', *Theory and Society* Vol. 28, No 1, 1999, p. 39.
[104] See Prigogine and Stengers, *Order Out of Chaos*, p. 287.

should the state be considered to be a geographically-contained black box[105] or mere nodal point.

To step back, it is important to not be swept away by a form of extreme liberalism or methodological individualism[106] when considering the increased permeability of the state. Conceptually, as an attractor, there is a degree of irreducibility present here, with the state clearly being 'more than the sum of individuals in the state system'.[107] Wendtian constructivism similarly does not deny this and continues the process of treating the state as unitary actor. The important issue here is that, unlike rationalist theories, identities and interest may change as states interact with other states.[108] Wendt privileges states to the point that he considers them, via what he calls 'corporate agency', to be 'people too' (and hence realists can speak of '"self" interested' states).[109] Consequently, states can then be understood as being embedded both culturally and institutionally within the international system, and not just in a material sense. This challenges a concept like balance of power, which is routinely held to be of a materialist image.[110] The intersubjectivity of states, with the latter still being the most dominant aggregates, should be understood as evolving from this context. The viability, permeability and permanency become defined by how the state is imagined, as Rosenau states:

> At some basic level sovereignty is thus a form of authority, an intersubjective state of mind in which the pressure for decisions to be made above or below the level of states are routinely rejected when the sovereignty myth is full in place, but which are

[105] In reference to black boxes see Stefano Guzzini, *Realism in International Relations and the International Political Economy: The Continuing Story of a Death Foretold*, Routledge, London, 1998, pp. 110-11.
[106] Ferguson and Mansbach, *Remapping Global Politic*, pp. 82-3.
[107] Colin Wight, 'State Agency: Social Action Without Human Activity', *Review of International Studies*, vol. 30, no. 3, 2004, p. 279.
[108] Harrison, 'Thinking About the World We Make', p. 9.
[109] Wendt, *Social Theory of International Politics*, p. 215. Wendt acknowledges that some difficulties exist in anthropomorphising the state. ibid., pp. 221-24. For further elaboration see Alexander Wendt, 'The State as a Person', *Review of International Studies*, vol. 30, no. 2, 2004, pp. 289-316. For a critique see Peter Lomas, 'Anthropomorphism, personification and ethics: a reply to Alexander Wendt', *Review of International Studies*, vol. 31, no 2, 2005, pp. 349-55. And the more than resounding reply read Alexander Wendt, 'How Not to Argue Against State Personhood: a Reply to Lomas', *Review of International Studies*, vol. 31, no 2, 2005, pp. 357-360.
[110] Jepperson, et al., 'Norms, Identity, and Culture in National Security', p. 33 and passim. This was also discussed at length in the previous chapter.

> evaluated and sometimes accommodated, if not outright accepted, when the myth has eroded and becomes problematic.[111]

Rosenau calls it a 'myth', but it is better understood as an imagined, shared reality, that is defined by how the dualism of structure and agency are thought to interact. On the one hand, the state, as a political unit, can be considered as a lasting aggregation that has developed as the core building block of an international political system. Both the building block and the system it resides in are informed by the metaphors and imagination that have cascaded from the dominant lens of the Newtonian paradigm. Conversely, the state can be considered a cultural artefact that emerges from its context,[112] meaning that 'certain macroscopic phenomena' arise 'via the nonlinear interactions of microscopic elements'.[113] Here, a different lens is provided via a different paradigm. The argument throughout the thesis supports the latter.

Complexity theorists have much to contribute in the matter of the development and interplay between aggregates in dynamical and complex systems. Rosenau depicts differing levels of aggregation within his concept of the post-international system[114] that are easily reconciled with Holland's tiers[115] and Kauffmann's patches.[116] For instance, Holland notes aggregation accommodates comprehension

---

[111] Rosenau, *Distant Proximities*, p.69.
[112] On the emergent properties of the state consider that 'Social and political institutions emerge from the interactions of individual humans and human groups. Groups may be local or national; they be loose-knit coalitions or adhesive groups of fervent followers, and may be more or less centrally organized. Out of the interactions among this mélange of groups and individuals emerges the set of institutions, people and practices that scholars call the "state."' Harrison, 'Thinking About the World We Make' p. 7.
[113] Klaus Mainzer, *Thinking in Complexity: The Complex Dynamics of Matter, Mind, and Mankind*, Spring-Verlag, Berlin, 1994, p. 1.
[114] Rosenau, *Distant Proximities*, ch. 3. Rosenau, *Turbulence in World Politics*, pp. 152-77.
[115] Again, as stated earlier, Holland's concept of 'tiers' whereby 'selecting appropriate characteristics, the theorist can limit the variation in the individual reaction rates within each aggregate', Holland, *Hidden Order*, p. 167. In this context the state could be interpreted as being a multi-agent in which all 'resources' are shared 'for the purpose of replicating the whole', Holland, *Hidden Order*, p. 136. In support of this, in what Holland refers to as a 'seeded aggregate collects resources rapidly enough to "pay" for the structural complexity, the seed will spread', ibid., p. 144.
[116] As stated in Chapter Three, to account for the diversity within and between systems, allowing for an appreciation of nested complex adaptive systems to develop, he uses a concept he calls 'patches' – in doing so he addresses how a level of autonomy (and with that free will) can develop in conjunction with a level of co-evolution that is not reliant upon a 'central administrator'. Further, Kauffman suspects 'that analogous of

and model-building,[117] and, consequently, increases the ability to understand the *complex* nature of things; a notion that can be extended to incorporate the state. Moreover, and most importantly, groupings also occur at multiple levels, with Holland's concept of 'meta-agents' best capturing this idea.[118] However, for Holland (and this is reflective of his perspective as a scientist) this is only appreciated as an hierarchical notion.[119] Yet, for the social scientist, as argued by Byrne,[120] such a set of arrangements can be interpreted as the preconditions of a nested order. Holland's articulation of aggregate formation acknowledges both boundary construction, and the hardening and softening of this, and the continual exchange of information, ideas, or materials across those boundaries, thereby supporting the maintenance, development or demise of particular groups.[121] Utilising the lessons of complexity theory, Rosenau places aggregates in a matrix that delineates between macro, micro, macro/micro, and macro/macro between what he imagines to be the main drivers behind a fragmenting world.[122] Accepting the state as a unit of analysis means accepting it as a construct that is semi-permeable and that its use will suit the need, desires, cultural setting both of the theorist and the individuals who live within states (and sub-sets). Yet care must always be taken when attributing 'characteristics' to states. Indeed, it worth remembering that:

> The fact that the state is, a 'complex institutional ensemble', constituted in and through, material resources, state practices

---

patches, systems have various kinds of local autonomy, may be a fundamental mechanism underlying adaptive evolution in ecosystems and cultural systems'. Kauffman, *At Home in the Universe*, p. 262-4.

[117] Holland, *Hidden Order*, pp. 10-11. To drive his point home Holland uses the analogy of the political cartoonist as modeller who 'must decide which features to make salient (exaggerate), and which features to eliminate (avoid), in order to answer the questions (make the political point)', ibid. p. 11.

[118] ibid., pp. 11-12, 135. As Neil Harrison argues 'The concept of meta-agents can be used in any issue area in which agents and actions at more than one level of aggregation are involved.' Neil E. Harrison, 'Thinking About the World We Make' in Neil E. Harrison, ed., *Complexity in World Politics: Concepts and Methods of a New Paradigm*, State University of New York Press, Albany, 2006, p. 9.

[119] Holland, *Hidden Order*, pp. 11-12.

[120] Byrne, 'Complexity, Configuration and Cases', p. 101.

[121] See Holland, *Hidden Order*, pp. 35-9.

[122] Rosenau, *Distant Proximities*, ch. 3 passim, see esp. table 3.1. Rosenau points of fragmentation, as the most distinct and as having differing and significant effects, across all four of his levels of aggregation: microelectronic technologies; skill revolution; organizational explosion; bifurcation of global structures; mobility upheaval; weakening of territoriality, states, and sovereignty; authority crises; globalization of national economies. ibid. And he states: 'Under conditions of high complexity they are all interactive, and each reinforces the others'. ibid. p.51.

> and discourses and differing structural configurations, and is endowed with political responsibility and recognised as a juridical subject, does not entail that it is a moral or psychological subject capable of independent action.[123]

How actors, whether they be states or other aggregates, are thought to operate within the international system is then constituted by how the dialectic between agency and structure is thought to play out. A non-linear appreciation attributes new significance to this debate.

Constituting Agency in an Emergent World

One of the most important lessons to be drawn from the study of complex systems is that adaptive agents learn.[124] Normative theories of international relations, in part, acknowledge this, as they look to move away from systemic and structural explanations that, in the words of William Wohlforth, emphasise 'material balances and invisible structural incentives'.[125] The acknowledgment that he makes, however qualified, is that normative approaches claim that structure is somewhat overstated, as actors have the ability to change 'their environment by changing the practices and norms that constitute it'.[126] The claim has also been made by Molly Cochran that the normative element is inescapable, in that all 'theory in international relations is normative theory'.[127] It is a worthy point and by it she means that:

> even those engaged in positivist approaches, who aim to study world politics in a manner that resembles as closely as possible the methods of natural science, cannot avoid normative assumptions in the selection of what is important, in interpreting that data, and in articulating why such research is significant.[128]

---

[123] Wight, 'State Agency', p. 278.
[124] See Holland, *Hidden Order*, pp. 80-5.
[125] William C. Wohlforth, 'Review Essay; Reality Check: Revising Theories of International Politics in Response to the End of the Cold War', *World Politics*, vol. 50, no. 4, 1998, p. 673. Of course, Wohlforth is most commonly associated with the realist school of thought.
[126] ibid. Unsurprisingly, Wohlforth is critical of the claim.
[127] Molly Cochran, *Normative Theory in International Relations*, Cambridge University Press, Cambridge, 1999, p. 1. Rosenau draws distinctions and significant correlations between normative and complex approaches. See Rosenau, *Distant Proximities*, ch. 9.
[128] ibid.

It should be noted that structuralist theories have attempted to incorporate the feedback-driven processes constituted by human agency, and in doing so have looked to lessons from the non-linear sciences. Some world system theorists, for instance, have sought to merge a complex understanding into a structuralist account by:

> conceptualizing individuals and human collectives, including cultures and nations, as *autopoietic* (self-maintaining) *dissipative* (environmentally dependent) structures whose essential features involved transformation of *energy* and the release of *entropy*.[129]

Analogously, the feedback and the emergent process of complex systems have had an immediate attractiveness, not least for the similarities that can be drawn to Marxist notions of a core and periphery dialectic. However, as Wight notes, although the activity of humans must 'always takes place in a structured social context',[130] it is the continually contested terrain of the significance of the role of structure vis-à-vis that of agency that most structural theories have difficulty reconciling. Indeed, this conflict between agent and structure has regularly been portrayed as constituting '*the* central problem in social and political theory'.[131] As a concept, Wight elegantly writes of its nature:

> The agent-structure problem emerged out of a set of concerns surrounding the development of adequate theoretical accounts of the ways in which people, through their interactions, constitute society and of how to integrate this with the social formation of those human agents.[132]

[129] Gunaratne, 'Thank you Newton, Welcome Prigogine', p. 125.
[130] Wight, 'State Agency', p. 275. Further, '…this context is integral to both the activity and its explanation. If the irreducibility of human action to social outcomes is accepted, then the state-as-agent solution is always going to be susceptible to a potential individualist riposte. This means that we have moved little beyond the original dichotomy.' ibid.
[131] Walter Carlsnaes, 'The Agency-Structure Problem in Foreign Policy Analysis', *International Studies Quarterly*, vol. 36, no. 3, 1992, p. 245. Carlsnaes, in his introduction, captures the essence of the agency-structure debate. He places it as the 'historical development of seemingly intractable dichotomies between "individual and society," "action and structure," "actor and system," "par and whole," "individualism and holism," and so on and so forth…' ibid.
[132] Wight, 'State Agency', p. 274. There is much written on this debate within in IR see, for example, Wendt, 'The Agent-Structure Problem in International Relations Theory', pp. 335-370; Jeffrey T. Checkel, 'The

Moreover, Wight captures the dilemmas inherent within the debate. He underscores how the prominence, or dominance of, either structure or agent is driven by the theoretical perspective:

> What this means is that one or other element becomes dominant and the other subordinate. For example, in structural-functionalism human agency appears lifeless and ghostly, whereas in phenomenological approaches – ethnomethodology, for example – structure assumes an ephemeral fragility. Eventually certain schools of thought repressed the subordinate element altogether. Thus for structuralist Marxism the acting subject became increasingly lifeless while the structural and/or cultural components seemed to enjoy a life of their own, self-propelling and self-maintaining. For interpretive sociology, on the other hand, human agency was sovereign with the structural banished to the realm of objectification and taking on a lifeless plasticity due to its constructed nature.[133]

As always, with debates of this nature, there exists a desire to find an alternative path. For example, Harvey seeks to integrate the role of agency via complexity and critical realism to what he refers to as 'naturalistic modes of social scientific explanation'.[134] His aim is to find the sought-after middle way; in this instance between that of 'positivism's fading path and the unchecked caprices of hermeneutic analysis'.[135] Others, coming from the same theoretical base, have made similar appeals:

> There should be room for both individual agency and social structure as influences on behaviour, with no insistence on reducing social action to one or the other. This would debar an individualistic reductionism that sees society only as an aggregation of individuals and also a structural reductionism

---

Constructivist Turn in International Relations Theory', *World Politics*, vol. 50, no. 2, 1998, pp. 324-48; Andreas Bieler and Adam David Morton 'The Gordian Knot of Agency—Structure in International Relations: A Neo-Gramscian Perspective', *European Journal of International Relations*, vol. 7, no. 1, 2001, pp. 5-35; Carlsnaes, 'The Agency-Structure Problem in Foreign Policy Analysis', pp. 245-70; Colin Wight, 'They Shoot Dead Horses Don't They? Locating Agency in the Agent-Structure Problematique', *European Journal of International Relations*, vol. 5, no. 1, 1999, pp. 109-42.

133 Wight, 'State Agency', p. 274.

134 Harvey, 'Agency and Community', p. 163.

135 ibid., p. 163.

> that sees structure as the only determinants of action. A non-reductionist ontology must comprise both individuals and social structures, along with the complex interrelationships between them.[136]

Although the scientism of Harvey, in particular, can be described as very thick,[137] his project does touch upon what can be offered to IR theory from the acceptance of presuppositions derived from a non-linear paradigm. Indeed, to return to the learning ability of adaptive agents within complex systems, any debate on structure and agency must not be built upon claims that agents and the function of them can be considered to be '"independently observable" phenomena' that can be reduced to mere components of a system.[138] This means that in examining the actions of agents, it must be realised that they cannot be separated, with any level of ease, 'from the social institutions in which they are routinely embedded'.[139] Effectively, this is an admission that intersubjectivity is a process of emergent phenomena,[140] and it is this that informs the relationship between agency and structure.[141] The consequence of accepting the nature of this relationship is that theory-making that offers a constitutive process will be better positioned to accommodate complex dynamics of far-from-equilibrium systems.

---

136 Jackson, 'Naturalism in Economics', p. 769.

137 Much in the same way Wendt describes himself as a 'thin' constructivist as opposed to the 'thick' radical constructivists. See Wendt, *Social Theory of International Politics*, ch. 1.

138 Rhee, 'Complex Systems Approach to the Study of Politics' p. 487. It is also important to stress that it is the multi-variance of levels that will complicate such claims.

139 Patomäki and Wight, 'After Postpositivism?, p. 230. This is the first of three reason as to why agents are not able to be separated from structure. The second is '*situated activity*' which bears a resemblance to emergence, and the third is '*context*', that is the depth and width of the historical and relational context. ibid., p. 231.

140 This can be understood as relating to consciousness itself as being 'representational mapping of the local surroundings'. Further, in accepting the ontological significance of emergence it should be noted that 'Intersubjectivity and language are necessary for both self-consciousness and institutions. We thus have to see the development of the psychological level and the sociological level as interconnecting.' Claus Emmeche, Simo Køppe And Frederik Stjernfelt, 'Explaining Emergence: Towards an Ontology of Levels', *Journal for General Philosophy of Science*, vol. 28, no. 1, 1997, pp. 112-3.

141 For example, Harvey selects elements of Roy Bhaskar's thoughts, bringing an unrealised concept (for Bhaskar) to the fore. This becomes acutely obvious when Harvey states that '… all social life is embodied in a network of social relations. This may be demonstrated by the mental experiment of subtracting from society the human agency required for it to be an ongoing affair. What we are left with are dual points of articulation of structure and agency, which are differentiated and processually changing positioned practices human agents occupied, engaged, reproduced or transformed, defining the (changing) system of social relations in which human praxis is embedded. Here again, on the relational model, we have the figure of a duality-with-a-hiatus, preventing a reductionist collapse in either direction', Harvey, 'Agency and Community', p. 174.

Links with constructivist thought are quite noticeable, with Wendt's thin constructivism that repeatedly deals with the dilemmas attached to the relationship between agency and structure.[142] Indeed, even some realists like Jervis acknowledge the need for '"structurationist ontologies" [to] replace the "dualism" of agency and social structure that pervades individualist and collectivist ontologies'. To make this important step would be to recognise the 'codetermined irreducibility' of both agent and structure.[143] Links to a complexity-informed 'non-reductionist ontology'[144] become evident. And it is here that Wendt's famous thesis that '[a]narchy is what states make of it' can be appreciated from the context of the role complex social processes play in shaping how states view one another. It is shown that theories that emphasise an a-historical and materialist explanation of international affairs cannot account for social elements. It is from this theoretical vantage-point that constructivists contend, by way of an example, that 'Canada and Cuba' may well have stood 'in roughly comparable positions relative to the United States', yet the examination of the respective relationship, of being a friend or foe, from a realist base 'will try to reduce cultural effects to epiphenomena of the distribution of power'.[145] As Wendt states, 'US military power may mean one thing to Canada, and another to communist Cuba'.[146]

It is important not to lose sight of the fact that in 'Wendt's world'[147] states remain, like in realist and liberal accounts, the dominant actors in world politics. The major difference is that they are entities whose decision-making[148] is constituted by an interplay between the social and the rational. Wendt seeks to achieve this

---

[142] See, for example, Wendt, 'The Agent-Structure Problem in International Relations Theory', pp. 335-370 or his *Social Theory of International Politics*, esp. ch. 4.
[143] Jervis, *System Effects*, p. 108.
[144] Jackson, 'Naturalism in Economics', p. 769.
[145] Jepperson, et al., 'Norms, Identity, and Culture in National Security', p. 34. The authors 'argue that these effects have greater autonomy'. ibid.
[146] Wendt, *Social Theory of International Politics*, p. 25. Rosenau seems to implicitly accept (or pre-empts) this when he states that 'whether it is local, national, or international politics that are of interests, one tends to be less concerned with what actors possess than with how they do or do not respond to each other.' Rosenau, *Turbulence in World Politics*, p. 184.
[147] See Steve Smith, 'Wendt's World', *Review of International Studies*, vol. 26, no. 1, 2000, pp. 151-63.
[148] Remembering that they are corporate agents.

feat by attempting to re-imagine rational choice so as to release it from its 'highly *deterministic*' goals.[149] On the other hand, he also acknowledges the 'Humean model of man',[150] but deems it inadequate, wishing to move beyond the 'dualism of desire and belief'. He searches, instead, for a 'cognitive theory of desire'.[151] Wendt's intention, and here he is dealing in the 'micro dimension',[152] is to step away from Humean dualism of belief and desire as separate entities, and acknowledges that they constitute each other.[153] What Wendt ends up presenting is a contingent rational choice model built upon foundations of scientific realism. Further, it is important to recognise that Wendt, by introducing cognitive psychology, helps to formulate a scientific basis for a theory of social construction. Importantly, his social constructivism seeks to develop a decision-making model that incorporates rational choice and reason, whilst still accepting the significance of the environment in shaping actors and their decision-making (or non-decision-making).[154] In essence, he provides a framework that explains that '[w]e want what we want because of how we think about it'[155] and, importantly, makes the point that '[d]esires are no less desires for being constituted by beliefs'.[156] The

[149] Wendt, *Social Theory of International Politics*, p. 126.
[150] ibid. On Hume and the passions see chapter 1. Wendt simplifies Hume, to an extent unfairly. As Kratochwil point out, 'since at least since Hume we know that our moral judgements do not stem from the recognition of the facts of the matter, but from the attitude we take towards them. Thus feelings of resentment and approval are crucial to our moral assessments even though these attitudes are not idiosyncratic indications of personal 'tastes'. It is simply not true that cognition plays no role, and 'reason is … just the slave of passion', as Hume sometimes maintained. He himself knew that this would make any deferment of gratification impossible and thus 'expected utility' would become a contradiction in terms. The mediations he proposed concern therefore, on the cognitive side, 'imagination' by which reason can conjure up 'future delights' and make them susceptible to assessment. But this means that reason must also have motivating power counteracting immediate desires. On the *emotional* side he develops – quite in line with other philosophers of the Scottish enlightenment – a distinct theory of 'sentiments', in particular of 'sympathy'. The latter, which he never tires to point out, is not grounded in 'self love', or the extension of the self, but on a genuine encounter with the concrete 'other' rather than with general 'humanity', conceived as a generalised ego.' Frederick Kratochwil, 'Re-Thinking the "Inter" in International Politics', *Millennium: Journal of International Studies*, vol. 35, no. 3, 2007, pp. 509-10.
[151] Wendt, *Social Theory of International Politics*, p. 119. Desire can be read as interests or preferences and beliefs as knowledge or expectations. Further' 'to some extent desire and belief *are* distinct phenomena. Desire is "for," belief "about." One is motivation, the other is cognition.' ibid., pp. 116, 119.
[152] Wendt, *Social Theory of International Politics*, p. 116.
[153] ibid. p. 126-7.
[154] See also Jeffery T. Checkel, 'International Norms and Domestic Politics: Bridging the Rationalist—Constructivist Divide', *European Journal of International Relations*, vol. 3, no. 4, 1997, p. 477.
[155] Wendt, *Social Theory of International Politics*, p. 119.
[156] ibid., p. 125.

'rationalist model of man'[157] is conditioned, and sits within such a cultural context. Essentially, his theory of rational choice, like his social constructivism, is very thin.[158] And, conversely, that he continues to refer to it as a form of rational choice appears to be more of a matter of convenience. Yet, grounding his idea of corporate agency in the presuppositions of complexity would significantly challenge his state-centricity. The state as a strange attractor, a high-energy and information-consuming entity, would alter the certainty in which it is held. It would impact the ability to imagine it as a whole, even if it be a whole with an identity.

Having said this, however, it must be observed that a grudging respect towards Wendt's constructivism has most certainly emerged; not least of all because his constructivism has not abandoned 'the notion that an external world' and that it remains 'cognitively approachable'.[159] Of course, how it is approached cognitively is framed by how scientific paradigms shape social thought. Wight, for one, does not reject the existence of an external world, but he nevertheless accepts that there exist boundary limits 'between the social world and the natural world' in respect to the 'dual notions of meaning and intentionality', and as such these properties are reserved for what he terms agents.[160] The next difficulty is to imagine what constitutes an agent. Is a state an agent or a structure? When seen as a part of an international system of states, it becomes an agent, but for the individual the state is generally perceived as a structure that contains and restrains behaviour. Wendt imagines it differently, with the state *being* equivalent to a person.[161] He recognises that individuals do contribute to the action of states, but only as interacting composites of the over-arching aggregate. He treats 'his individuals as little more

[157] He states in a footnote 'That it may be a model of *man* is an important issue that I shall pass over here.' He then directs the reader elsewhere should they be interested in a 'feminist critique of rationalism'. Wendt, *Social Theory of International Politics*, p. 116.
[158] Wendt, *Social Theory of International Politics*, pp. 117, 125.
[159] Knutsen, A *History of International Relations Theory*, p. 280. This point refers to empiricists within constructivism.
[160] Wight, 'State Agency', p. 274. However, it is probably important to clarify even further it would perhaps be best to refer to social agents (as agents can exist in, for example, chemical processes). Here again, the viability of a complexity/critical realism blending is evident.
[161] Alexander Wendt, 'The State as Person in International Theory', *Review of International Studies*, vol. 30, no. 2, 2004, pp. 289-316.

than nodal points through which structural agency is exerted'.[162] Yet states are not, nor do they act like, people, and personifying the state is an act of anthropomorphising agency.[163] The state, for Wendt, represents the *literal* embodiment of a 'person', as opposed to 'scientifically orientated IR scholars', inclusive of positivists, who have personified the state 'as an instrumental device aimed at facilitating explanation'.[164] As Wight correctly points out: either approach strips 'the social field of human agency', and therefore 'we have agency, but no human activity'.[165]

Indeed, as an example, the 'individual variable' (the agency) of a monumental figure like the last Soviet President, Mikhail Gorbachev, should not be overlooked. The 'international environment' did not prescribe, or necessarily induce, Gorbachev's reforms, although it did, of course play a role. Change, as it played out, was not inevitable.[166] Even more radically, as Rosenau argues, it matters little that individuals at the micro-level need be aware that their behaviour may

[162] Wight, 'State Agency', p. 276. See also Smith, 'Wendt's World', pp.161-2.
[163] Wight, 'State Agency', pp. 273-4. Although not always embodied as a person. Take George Keenan less than flatteringly analogy of the American electorate who, for him, resembled 'one of those prehistoric monsters with a body as long as this room and the brain the size of a pin: He lies there in his comfortable primeval mud and pays little attention to his environment. He is slow to wrath – in fact you practically have to whack his tail off to make him aware that his interests are being disturbed; but once he grasps this, he lays about him with such blind determination that he not only destroys his adversary but largely wrecks his native habitat'. This is representative of the '*impulsive model*' of foreign policy making (which can add a volatility to the actions of states); Miroslav Nincic, 'The United States, the Soviet Union, and the Politics of Opposites' *World Politics*, vol. 40, no. 4, 1988, p. 457. See also Rosenau, *Turbulence in World Politics*, p. 146.
[164] Wight, 'State Agency', p. 269.
[165] ibid, pp. 269-70. This can be contrasted nicely by a similar dichotomy pressed by Vico in relation to the anthropomorphising of natural world vis-à-vis the scientific rationalism foisted upon the social world. Berlin explains, as always, at length: 'If anthropomorphism was to falsely endow the inanimate world with human minds and wills, there was presumably a world which it was proper to endow with precisely these attributes, namely, the world of man. Consequently, a natural science of men treated as purely natural entities, on a par with rivers and plants and stones, rested on a cardinal error. With regard to ourselves we are privileged observers with an 'inside' view : to ignore it in favour of the ideal of a unified science of all there is, a single, universal method of investigation, was to insist on wilful ignorance in the name of a materialist dogma of what could be known. We know what is meant by action, purpose, effort to achieve something – we know these things through direct consciousness of them. We possess self-awareness.' Berlin, *Against the Current*, The Hogarth Press, London, 1980, p. 96. Singer, predating the debate, alludes to some concerns in respect to the anthropormising of the state. Singer, 'The Level-of-Analysis Problem in International Relations', p. 88.
[166] Vasquez, *The Power of Power Politics*, p. 328. '… domestic politics is crucial because it may give rise to leaders with different ideological perspectives and these differences will not be smoothed out by the external environment, as realists assume.' ibid., p. 339. Vasquez explains further: 'The Cold War came to an end because a leader (Gorbachev) eventually emerged on one side that was able to initiate a series of actions that would break the cycle of arms racing and competing for client states, as well as the hostility and propaganda to which each side inured. These actions which often took on the characteristic of unilateral unreciprocated actions, eventually produced a positive response by a leader (Reagan) who was able to control hard-line critics who had previously undermined accommodation'. ibid., p. 366.

influence what occurs at the macro-level.[167] Even if there is a level of awareness, there will always be a level of ignorance present, in that the behaviour may result in unexpected outcomes. Further, being able to attribute how the actions of a few might have a subtle influence on macro-level structures is difficult, except in the most extreme cases (for example, those that fly planes into buildings). This is paradoxically set against the importance of understanding that the consistent conduct of individuals within 'their cultures, enrich, reinforce, or otherwise sustain the dynamics that configure the ways in which people and their collectives interact'.[168] Again, the point here is one of significant points of attraction. Of course, these attractors are maintained by high energy, far-from-equilibrium processes that are potentially sensitive to variation. Because of this deviation from regular patterns can produce pronounced effects. Alternatively, there may be no discernable effect at all. This is indicative of the existence of an increasingly complicated and contradictory world, one which is witnessing a 'proliferation of identities', both in respect to the number of cultural groups that can be identified and the fact that people can have more than one identity.[169]

Rosenau incorporates the ideas that flow from the complexity theory into his analysis, attaching to his vision of global politics the nested nature of complex systems and the manner in which various sub-systems interact. Yet Wendt too, in his later work, seeks to attach the authority of the non-linear science to his analysis. Stepping beyond his three logics of anarchy, outlined in his *Social Theory of International Politics*,[170] Wendt argues that a world state is inevitable. The desire, the Hegelian 'struggle for recognition', is the determining factor that drives the system to its purported teleological endpoint.[171] Extending beyond Hegel's

[167] Rosenau, *Distant Proximities*, p. 76. Micro and Macro can be taken to also mean agency and structure. See Carlsnaes, 'The Agency-Structure Problem in Foreign Policy Analysis', p. 245.
[168] Rosenau, *Distant Proximities*, pp. 76-7. Of special interest here is the work of Clifford Geertz. His work, centring on the development of interpretive cultural systems, whether they be religious, cultural or some other formulation, could easily be accounted for as forms of strange attractors. See Clifford Geertz, *The Interpretation of Cultures*, Basic Books, New York, 1973.
[169] ibid., ch 8. esp. pp. 187-8.
[170] Wendt devises 'three cultures of anarchy'; Hobbesian, Lockean, and Kantian. Wendt, *Social Theory of International Politics*, ch. 6.
[171] Wendt, 'Why a World State is Inevitable', p. 493.

endpoint of a system of states, Wendt concludes that the only stable final point is when an equality of recognition occurs. The inherent asymmetry of a state-based system precludes Hegel's (or Fukuyama's) claim of an 'End of History'. Nor can it allow for a Kantian 'pacific federation'. They are, in fact, progressive steps towards an inevitable world state.[172] For Wendt, the logic of anarchy is as much about recognition as it is about security.[173] Indeed, recognition defines the very nature of anarchy, as it 'is a social act that invests difference with particular meaning – another actor'.[174] Ultimately, while the current asymmetry of the state-based system is unstable, these 'local attractors' cannot endure, as groups, nations, states and individuals will continue to seek recognition – violently, if need be.[175]

Wendt speaks of theories of self-organisation from this perspective, with attractors being end-states. Moreover, he attempts to introduce the language of complexity with a basic interpretation of phase transitions. In this regard, he argues:

> that they come in four types – fixed-point (corresponding to equilibria in economics), periodic, qausi-perodic and chaotic. Each represents a distinct pattern toward which a system may move and lock into, after which it settles down into a self-sustaining logic. We might say that a system is then organized as opposed to organizing, even though an organizing process is important for its survival. Which attractor characterizes a given system depends on its boundary conditions. Waltz's claim that anarchy tends towards balancing (and thus continued balancing) implies a fixed point attractor, as my claim that it tends toward a world state.[176]

From this, Wendt goes on to add that 'territorial states are not stable in the long run. There may be local equilibria, but they inhabit a system that is in

[172] ibid., pp, 493, 510-11. The idea of a theoretical endpoint being reached requires a single point in the realm of ideas to remain static, to not evolve and to be impermeable to shifts to how the world is perceived and understood. This is not to say that, for example, history would end, in the manner that Francis Fukuyama's argument is often misrepresented. For his spirited defence see Francis Fukuyama 'Reflections on the End of History, Five Years Later', *History and Theory*, vol. 34, no. 2, 1995, pp. 27-43.
[173] Wendt, 'Why a World State is Inevitable', p. 510.
[174] ibid., p. 511. It is also important to appreciate that 'two actors cannot recognize each other as different without recognizing that, at some level, they are also the same.' ibid. p. 512.
[175] ibid. pp. 507, 512-14.
[176] ibid., p. 501.

disequilibrium, the resolution of which leads to a world state'.[177] Wendt's argument is clever. He is right that 'group identity is a process not a thing' and that 'collective identity formation' will always emerge. Yet, his 'stable end-state' argument built on a 'development path'[178] does not lie too far from Scottish Enlightenment thinker and 'father of sociology' Adam Ferguson, whose ideas of stages of development from 'barbarism' to 'civilization'[179] are entrenched in a linear and cumulative understanding of human society.

There is also an amorphousness to Wendt's idea of a world state. The latter does not necessarily have an army, nor must its economy, culture or politics be collectivised. Indeed, he is not even speaking of a world government.[180] Why Wendt calls it a state (as opposed to a society) is not altogether clear. What is even less clear is why it is teleological in nature.[181] There may well be a 'progressive "amplification" of intentionality from individuals and groups to the global level',[182] but the *points* (not *point* in the singular, as Wendt argues) of an attractor are not an end-state.[183] If a teleological claim is to be made then it can be extended no further than this: order will always arise and, if uninterrupted, the nature of that order will increase in complexity. Moreover, if the state were to cease to exist, or at least to evolve into something quite separate from how it is imagined in contemporary political discourses, it would merely be replaced by some alternative level of aggregation.[184] It is here that Wendt's argument would be

---

[177] ibid, p. 507

[178] ibid., pp, 493, 520. Admittedly, in respect to the development path, he argues that the system may move forward, back and even skip stages. ibid.

[179] Lisa Hill, *The Passionate Society: The Social, Political and Moral Thought of Adam Ferguson*, Springer, Dordrecht, 2006, pp. 4-6, 65-9.

[180] Wendt, 'Why a World State is Inevitable', p. 506. Further, he contends, that 'Universalism, in short, depends on recognition of particularism. World state formation is not only a cosmopolitan process, but a communitarian one as well.' ibid., p. 516. Of course, there is nothing wrong with this idea and it can nestle quite neatly with complexity inspired approaches. The point of interest is how it attached to a definition of the state that is so loose as to be unhelpful.

[181] Indeed, his talk of intentional and non intentional faces of teleology are far from convincing and rest more on arguments of convenience For example, on the possibility of considering rational choice theory as (intentionally) teleological because of its goal-seeking nature he merely states its contested nature. ibid., p. 496.

[182] ibid., p. 530.

[183] As discussed in Chapter Three. See presuppositions two, three and four.

[184] Self-organisations illustrates that social construction can be viewed as 'natural'. Not in the sense of genetic reductionism but in that complex order will always emerge in some form in systems that can be

better situated. As it stands, however, the main difference rests on his conviction that this imperative to order and increasing complexity will somehow result in the establishment of an ill-defined world state. Instead, this thesis argues that multiple equilibria will continue to exist in, and between, human societies. This will occur irrespective of whether they are conceived as a society of states, a global society or a world state. In turn, the continual interplay of multiple equilibria will always result in the evolution of new structures and new points of attraction. All of this does not mean that a world state, as loosely envisaged by Wendt, will not emerge. Instead, it denies that an individual is to a world state what an acorn is to an oak tree.

If it is accepted that multiple equilibria define the nature of global politics, how, then, might a non-linear, informed theory interpret the relationships between individuals, organisations, states and an overarching and constitutive international system or systems? The first step is to ensure that there is no *a priori* assumption 'that the basic structures and processes of international politics remain intact even as change swirls through its component parts'.[185] The second is to imagine that the global system is (or systems are) poised between order and chaos, and, further, to accept that the world is both natural *and* social. Moreover, it is a world 'that knowledge must describe'.[186] The final step is to accept Wendt's own tentative step beyond state-centrism, when he asserted that 'Anarchy is (still) what states (and other actors) make of it'.[187] As the next section details, acknowledging complex adaptive systems is acknowledging the constitutive relationship between agency and structure across multiple levels.

designated as functioning at the edge of chaos. For example see Susan McKinnon and Sydel Silverman, eds, *Complexities: Beyond Nature and Nurture*, University of Chicago Press, Chicago, 2005.
185 Rosenau, *Turbulence in World Politics*, p. 18.
186 Byrne, 'Complexity, Configuration and Cases', p. 96.
187 Wendt, 'Why a World State is Inevitable', p. 529.

Global Complex Adaptive Systems

At an essential level, when attempting to understand contemporary international politics, the 'simple ideas of cause and effect' can be said to 'no longer apply'.[188] This is an idea that must transcend the importance attributed to turning points. Change in a system should not necessarily be isolated to the cataclysm of significant events. This is because the events are a part of greater processes that have permitted, encouraged, or are a reaction to the evolution and emergence of a particular set of arrangements. Consider the build up to the end of the Cold War. Complexity theorist Stuart Kauffman compares the nature of change to that of a log-jam, and reveals how the patterned behaviour that had occurred for a long periods of time could be undone by the smallest of movements:

> When Mikhail Gorbachev began speaking about *glasnost*, we knew that something big might happen. We knew that a move to open the closed Soviet society to its own people's concerns might unlock a revolution. We knew that the small steps might lead to vast transformations. Yet while we knew this intuitively, and the pundits pummelled us with their insights, we did not really know what we intuited. We did not understand how the logs of the logjam fit together, such that removing one particular log will cause the logjam to shift only slightly, while another, innocuous in its position, will unleash the whole mass to swarm downriver.[189]

Hence, a single event should not be overvalued (nor undervalued), as it will dismiss the complex nature of change. Yet, although caution should be exercised with proclamations of historical turning points, especially when the shift is portrayed as a completely 'new order', it is difficult to ignore the seductiveness of such claims.[190] Former US Secretary of State Colin Powell, in response to the attacks of September 11, captured this sentiment in a manner that would appeal to

---

188 Dana Mackenzie, 'The Science of Surprise: Can Complexity Theory Help us Understand the Real Consequences of a Convoluted Event Like September 11', *Discover*, vol. 23, no. 2, 2002, p. 59.

189 Kauffman, *At Home in the Universe*, p. 299.

190 Kal J. Holsti, 'The Institutions of International Politics: Continuity, Change, and Transformation', Paper presented at the Annual Meetings of the International Studies Association, New Orleans, Louisiana, March 23-27, 2002. Much has been made of the consequences of September 11; a former national security advisor to Vice President Al Gore suggested that September 11 would be remembered as a demarcation point for US foreign policy, with starkness comparable to that of BC and AD. Robert S. Litwak, 'The Imperial Republic After 9/11", *The Wilson Quarterly*, vol. 26, no. 3, p. 76.

scholars of international relations: 'not only is the Cold War over, the post-Cold War period is also over'.[191] Indeed, September 11 can be appreciated as one of the first true 'global memories'.[192] However, such 'big bang' theories not only ignore the complexities of change,[193] but they fundamentally undermine theoretical attempts to understand the international system in any meaningful way. Linear theories do not make sufficient space for understanding the relationship between continuity and change, in particular, how major change in a 'nonlinear dissipative complex' system, like the international system, occurs when, via the multiplicity of non-linear interactions, parameters change, and at times dramatically. This can then result in destabilising 'old structures'.[194]

Hoffmann notes that the emerging tensions in the post-Cold War world before September 11 were fundamentally tied to the notion of globalisation. Hence, it was less a clash of civilizations and more a case of a clash between the fragmentation of both states and the state system vis-à-vis the continuing 'progress of economic, cultural, and political integration'.[195] In essence, this led to claims that ignoring asymmetries within the system illustrated that interconnectedness could not be ignored, and as much as 'the US may not be interested in what happens in faraway places, those faraway places are interested in it'.[196] Deductively, positive feedback could be incorporated into theoretical accounts noting that the intensification of globalisation[197] has facilitated in pushing the system away from expected outcomes. Moreover, it could be argued that it has contributed to the

[191] Litwak, 'The Imperial Republic After 9/11', p. 76.
[192] Wendt, 'Why a World State is Inevitable', p. 523.
[193] Holsti, 'The Institutions of International Politics'
[194] Mainzer, *Thinking in Complexity*, p. 4.
[195] Stanley Hoffmann, 'Clash of Globalizations', *Foreign Affairs*, vol. 81, no. 4, 2002, p. 104. Hoffmann's point runs counter to Samuel Huntington's 'clash of civilizations' thesis. Huntington's thesis integrates a simplistic and ill-informed notion of identity and marries it to a realist conception of power (in many respects his civilisations are super states). For further reading see Huntington, *Clash of Civilizations*, passim.
[196] Smith, 'The End of the Unipolar Moment', p. 175. Additionally this has been taken to mean that the United States can no longer ignore failed states, even if they are located in an area that is not considered to be of vital national interest. Litwak, 'The Imperial Republic After 9/11', p. 82. Again, how a reaction to this revelation plays out is tied to how cause and effect is understood. September 11 is an example of when the system bites back, in policy terms this is referred to as 'blowback', or, in the language of complexity, feedback. See E. Goh, 'Hegemonic Constraints: the Implications of 11 September for American Power', *Australian Journal Of International Affairs*, vol. 57, no. 1, 2003, pp. 89-92.
[197] Arguably globalisation can be seen as continuation of age-old globalism. See Robert O. Keohane and Joseph S. Nye Jr., 'Globalization: What's New? What's Not? (And So What?)', *Foreign Policy*, Spring 2000, p. 108. This is also indicative of a scaling effect.

embedding or even the exponential rise of asymmetries within the system. From this perspective the heavily-networked international society should be viewed as one of the most significant developments in recent times, yet it is not nearly as seductive as the collapse of the Soviet Union or major terrorist attack upon the global hegemon.[198] Globalisation is the:

> acknowledgement of the independent role of both transnational entities – corporations, non-governmental, social and political organisations of many kinds – and intergovernmental organisations and regimes. Its focus is on how territorial sovereignty as the ordering principle for human activity has been redefined, and in some ways transcended, by networks of interaction that involve actors of many different levels, and that feed off the huge technological and social improvements in the capacity for transportation and communication of nearly all types goods, information, and ideas.[199]

The 'clearest guiding theme is the deterritorialisation of world politics',[200] and with this emerges the multiple networks that overlap and inform and reinform around dominant points of attraction. States, as has been argued, maintain their relevance, but, as Rosenau has counter-argued, thereby illustrate the constitutive nature of structure and agency:

> the proliferation of organizational networks contributes to bridging the gap between people at the micro level and their collectives at the micro level. It offers a vast array of routes through which individuals can move among the local, global, and private worlds. It also sustains the dynamics of deterritorialization, the spread of the skill revolution, and the continued salience of distant proximities. If hierachically structured states still dominated the course of events and were thereby able to contain and control the vibrant spread of horizontal networks, it is doubtful whether a new epoch would be emerging. For better or worse – and given the vitality of the

198 Of course, both the latter events are significant. The important point is that the common desire to concentrate on 'turning points' as indicators of real change can mask more subtle but equally (if not more) transformative changes. In respect to both the demise of the Soviet Union and the attacks of September 11 it should also be noted that the importance of the two events in the global psyche or memory was facilitated by the processes that underpin globalisation.

199 Buzan and Wæver, *Regions and Powers*, p. 7.

200 ibid., p. 7.

> drug trade and crime syndicates, sometimes for worse – the ever greater salience of organizational networks is serving to restructure the underpinnings of world affairs.[201]

International affairs can be understood as becoming increasingly difficult for states to navigate. As multiple paths, distributed across multiple levels, emerge and interconnect, then feedback loops result in continual change[202] that need to be, and are, continually adapted to. The consequence is that any action may '… set in motion a train of events that will likely come back and form a different pattern for us to adjust to'.[203] Therefore, any view that a 'hyperpower' can, for example, act independently of international institutions and agreements, norms of behaviour, the global economy, or even of private citizens and non-government organisations, displays little appreciation of how agency cuts across multiple levels and carries significant influence. When viewed from traditional state-centric theories, unilateralist action, to stay with the example of the US, are less able to incorporate how such actions undermine the ability of the global hegemon to maintain influence.[204] Thus, to look at it from a state-based perspective, the loss of freedom the US experiences by constraining its unilateralist desires far outweighs the negatives associated with that of a belligerent and self-interested hegemon.[205] In effect, both the primacy and the security of the US relies not, it has been argued, in its ability to 'go it alone', but in its ability to remain 'embedded in a legitimate

---

201 Rosenau, *Distant Proximities*, p. 62. Even Paul Kennedy has acknowledges the potentiality of communication and technological advancement upending traditional structure of world politics. Kennedy, *The Rise and Fall of Great Powers*, p. 440. See also Rosenau, *Turbulence in World Politics*, pp. 112-3.

202 And 'loaded' continuity – like logjams.

203 Waldrop quoted in Bronk, *Progress and the Invisible Hand*, p. 81. Waltz touches on the importance of initial conditions yet it is fleeting and tied quite heavily to his concept of structure. Basically he ties it into the notion of 'equifinality', which suggest multiple paths in open system yet still reaching the same endpoint. Waltz, *Theory of International Politics*, p. 78. He also hints at self-organisation. ibid., pp. 75-6.

204 Moreover, this is underscored when the very basis of globalisation is built upon the Western alliance, which the Bush administration seriously undermined. John Micklethwait and Adrian Wooldridge, 'Rebuilding the Politics of Globalization', *The New York Times*, April 13, 2003, p. 6.

205 Hoffmann, 'Clash of Globalizations', p. 113. This is similar to John Ikenberry's argument that the limiting of power by a hegemon is a curious historical occurrence that has arisen because of the ability of secondary states to receive 'institutional assurances 'the will protect them from exploitation. For the hegemon such an institutional arrangement allows for the longevity of its power base.. Ikenberry explains this as an arrangement in which the 'hegemonic state obtains commitments from secondary states to participate" in the Western based international system whilst the hegemon in return 'places limits on the exercise of its power' G. John Ikenberry, 'Institutions, Strategic Restraint, and the Persistence of American Postwar Order', *International Security*, vol. 23, no. 3, Winter 1998, pp. 43-4.

world order'.[206] Yet, merely theorising how the mitigation of power should occur in order to maintain a peaceful status quo position is reflective of a dynamically *conservative* view of affairs. High energy, far-from-equilibrium systems *never* settle down.

What it means to be legitimately embedded within a particular world order has been absorbed by neoliberal theories of international relations. Most notably, Keohane and Nye advocate their theory of neoliberal institutionalism, which they call complex interdependence. The latter identifies the 'absence of hierarchy among issues', the increased networking, which they call 'multiple channels', across different levels, and a greatly reduced role for the use of military force.[207] The authors also have an awareness of non-linear thought by drawing their own parallels with the concept of sensitivity to initial conditions.[208] Examples abound: for instance, the 'contagion effect' felt during the Asian Financial Crises fits into this category of economic interdependence. What began with currency speculation on the Thai baht in early 1997 resulted in a contagion effect that severely impinged upon many economies in Asia. Arguably, the worst-affected country was Indonesia where the currency depreciated acutely (moving from Rp.2,400/US$ to Rp.15,000/US$) and inflation peaked at 77.6 per cent.[209] IMF reforms in Indonesia resulted in a dramatic increase in the cost of living, notably in the prices of rice,[210] electricity and petrol.[211] Riots ensued, and by the following May, after 32 years in power, Soeharto was forced to resign.[212] Keohane and Nye's theory can absorb the end result of political change, as they stress that social and political contagion can

[206] Guzzini, ''Foreign Policy Without Diplomacy', p. 296.
[207] Keohane and Nye, *Power and Interdependence*, pp. 22-5.
[208] Keohane and Nye, 'Globalization: What's New? What's Not? (And So What?)', pp. 112-13.
[209] Srawooth Paitoongpong, 'Social Implications of the Asian Economic Crisis in Thailand, Indonesia, Malaysia and the Philippines: Synthesis Report', *TDRI Quarterly Review*, vol. 16, no. 1, 2001, p. 5.
[210] Not only did the price of rice increase but the drop in real wages (and hence income) resulted in many commodities becoming too expensive. Iwan J. Azis, ,The Nonlinear General Equilibrium Impact of the Financial Crisis and the Downfall of Manufacturing', *The Developing Economies*, vol. 38, no. 4, 2000, pp. 530-1, 537.
[211] The price of petrol increased 70 percent and electricity rates by 60 percent. Amy L. Freedman, 'Economic Crises and Political Change: Indonesia, South Korea, and Malaysia', *Asian Affairs: An American* Review, vol. 31, no. 4, 2005, p. 240.
[212] The fall of Soeharto can be interpreted as a 'potent sign of the connections between political and economic change', Robert Garran, *Tigers Tamed: The End of the Asian Miracle*, Allen & Unwin, St. Leonards, 1998, p.137.

also occur.[213] Yet, their networks, even when they move beyond simplistic 'hub and spoke' analogies, are void of any emergent depth. While they are correct in stating that the 'architecture of networks of interdependence varies according to the different dimensions of globalism',[214] they are unable to accept that emergent structures are not bound by traditional conceptions of a state-centric system.[215] The issue rests in the ontological similarities between (neo) realism and (neo) liberalism. Indeed, in the absence of a complex interdependent situation the authors happily concede that the traditional realist perspective would best suit.[216] Thus, the proliferation of NGOs, which interact between differing aggregate levels with ease,[217] or the vulnerability of 'modern societies', due to the growing richness of global networks,[218] cannot be effectively accounted for. They are, in effect, and despite attempts to be methodologically inclusive of lessons from complexity, paradigmatically-bound.

If, however, globalisation is taken as a representation of a recurrent network, and as a descriptor of the current international system which the state, dominantly, but not exclusively, can be seen to inhabit, then an idea of a global complex adaptive system (that of many overlapping systems) can emerge. This means, of course, that emergent properties of the system can be understood as arising from the relationship between the positive feedback (the 'locking in') of actions with the surrounding environment.[219] From this, a theory of international emergence (with the complex adaptive system at its centre)[220] could possibly be considered.

---

[213] Keohane and Nye, *Power and Interdependence*, p. 11.
[214] ibid., p. 257.
[215] Rosenau, *Distant Proximities*, pp. 56-62.
[216] Keohane and Nye, *Power and Interdependence*, p. 31.
[217] Rosenau, *Distant Proximities*, pp. 56-62.
[218] In effect, this means that it much easier (for a terrorist, activist etc.) to attack the proverbial cog in the system causing feedback and cascading effects that can reverberate throughout the whole system. Homer-Dixon, 'The Rise of Complex Terrorism', pp. 55-58. In respect to how complex networks feedback in an emergent world it could be argued that the US led counter terrorism campaign has succeeded in compelling 'an already highly decentralized and evasive transnational terrorist network to become more 'virtual' and protean', in effect making it more difficult to identify and remove. International Institute for Strategic Studies annual report, *The Military Balance*, quoted in Richard Norton-Taylor, 'Iraq has Swollen Ranks of al Qaeda', *The Guardian*, October 16, 2003, p. 17.
[219] Tim Blackman, 'Complexity Theory' in Gary Browning, Abigail Halcli and Frank Webster, eds., *Understanding Contemporary Society: Theories of the Present*, Sage Publications, London, 2000, p. 141.
[220] Rosenau has certainly worked towards such an idea (see *Turbulence in World Politics* or *Distant Proximities*). However, more recently Kavalski has attempted to situate in complexity as part of a fifth debate

Rosenau, a pioneer in this area, provided a basic description-cum-definition as a starting point:

> At the core of complexity theory is the Complex Adaptive System – not a cluster of unrelated activities, but a system; not a simple system but a complex one: and not a static unchanging set of arrangements, but a complex adaptive system. Such a system is distinguished by a set of interrelated parts, each one of which is potentially capable of being an autonomous agent that, through acting autonomously, can impact on the others, and all of which engage in patterned behaviour as they sustain their day-to-day routines or break with the routines when new challenges require new responses and new patterns. The interrelationships of the agents is what makes them a system. The capacity of the agents to break with routines and thus initiate unfamiliar feedback processes is what makes the system complex (since in a simple system all the agents consistently act in prescribed ways.) The capacity of the agents to cope collectively with the new challenges is what makes them adaptive systems such then is the modern urban community, the nation state, and the international system.[221]

Briefly, the concept of a global complex adaptive system would attach itself to theories of IR that could, in turn, absorb and evolve from the constitutive assumptions that arise from it. Any theory or analysis, and there is a symbiotic relationship here, would need to accommodate the presuppositions as laid out at the beginning of the third chapter.

The consequence of absorbing complexity would result in, for example, having to accept that the rate and nature of interactions are not only bound by history, but also by ignorance. The agents within a system, therefore, can never be fully aware of all the complexities and are, consequently, ignorant to the system as a whole.[222] Within a closed determinist system, the linear relationship, in principle, allows for the assumption as to the possibility of global knowledge; an open non-linear

---

where he posits the idea of the 'emergence of complex international relations theory'. See Kavalski, 'Emergence of Complex International Relations Theory', passim.

[221] James Rosenau, *The Study of World Politics: Theoretical and Methodological Challenges*, vol. 1, Routledge, New York, 2006, p. 111.

[222] Cilliers, *Complexity and Postmodernism*, p. 4.

system with borders that are difficult to define, denies knowledge of the whole. The consequence of this is that it is impossible to determine concrete outcomes of an emergent process. The constitutive relationship between agency and structure remains contextual and indeterminable. In this light, globalisation may well be understood to have shrunk the world to a level where interactions of various natures criss-cross the globe, but agents only deal with their own 'glocal'[223] concerns. This could represent members of their local community, a neighbouring state, or a business or like-minded activist who is geographically distant. Nested and multiple overlapping complex adaptive systems would define the international environment.

Furthermore, a 'final' form could not be realistically entertained: equilibrium is akin to death, and constant dynamism is prevalent even in the in the routines of day-to-day life.[224] This dynamism and constant interplay between the domestic and the international means that the 'two are defined in endless mutual adjustment that constantly redefine the state itself'.[225] Indeed, the dualism in itself is open to be challenged. Because of this, as time passes and the warnings of alarmists and doomsayers begin to fade, it will become difficult to view a process like globalisation as a purely 'hard hegemonic force', given the uncertainty, complexity, and the varying degrees of interdependence surrounding the notion.[226] Globalisation should be viewed as being part of a wider emergent trend that has developed into a semi-autonomous and self-organising process. Hence, it should not be viewed as a reversible process that represents the whims of hegemonic influences within the international system.[227] Essentially, this continues the state of flux that denotes a non-equilibrium dynamical system. Finding absolute answers to the nature of the relationships between the points of attraction becomes a far more difficult process.

---

[223] See Neil Brenner, 'Global Cities, Glocal states: Global City Formation and State Territorial Restructuring in Contemporary Europe', *Review of International Political Economy*, Vol. 5, no. 1, 1998, pp. 1-37.
[224] Hoffmann and Johnson, 'Change and Process in a Complex World', p. 3. Wendt disputes this. See Wendt, 'Why a World State is Inevitable', p. 502.
[225] Clark, 'Beyond the Great Divide', p. 481.
[226] Geyer, 'Future of Scandinavian Exceptionalism', pp. 561-62.
[227] Clark, 'Beyond the Great Divide, pp. 483-84.

Returning Intuition and Interpretation - Conclusion

Keohane and Nye are correct in writing that 'there will never be a substitute for careful analysis of actual situations'.[228] Yet, what is unfortunate is that all too often the metatheoretical foundations of any given analysis are either not declared or there exists a lack of awareness of them. Here lies the issue with paradigms as laid out by the mature sciences. Established practices mixed with traditions and customs within the field help to preserve dominant approaches,[229] which, in turn, have informed the nature of social science. For example, Thayer, who looks to construct a reductionist 'evolutionary realism',[230] finds Waltz to be an improvement on classical realism as his work is 'more scientific'. He feels that evolutionary theory can improve the structuralist approach because 'it places the theory on a scientific base for the first time'.[231] Thayer concludes with the sobering thought that, because of our genetic composition, ethnic conflict, along with war and peace, will continue to remain a 'part of the fabric of international relations'.[232] His is a claim of scientific truth and certainty. And, ironically, it depicts a distance between the scientific and social imagination.[233] The advent of the non-linear sciences has indicated that 'man'-the-artist and 'man'-the-scientist operate in worlds not too distant from each other. As Cilliers writes:

> Artists through the ages have attempted to find new ways of portraying and understanding the complexities of our world. Under certain conditions, a good novel may teach us more about

[228] Keohane and Nye, *Power and Interdependence*, p. 4.
[229] Lugg, ''The Priority of Paradigms' Revisited', p. 176.
[230] Thayer, *Darwin and International Relations*, p. 79. This was touched upon in Chapter One.
[231] ibid., pp. 64-5
[232] ibid., p. 265.
[233] Heinz Herrmann conveys an essence of this distance when he wrote the 'The gap between the perception of the physical universe and the experience of human existence has never been so great as in recent times. Beginning in ancient Greece, the human mind developed a basic need to encompass the diversity of nature by substituting simplifying abstractions… Following the Copernican Revolution and the establishment of Galilean-Newtonian mechanics, scientific thought has tended toward subsuming the diversity of phenomena under a single "Final Theory"… These advances have engendered the attitude that all forms of understanding, even those pertaining to life and human existence, should follow some type of simplifying abstraction and that those introduced by physics are the only models of understanding worth consideration.' Heinz Herrmann, *From Biology to Sociopolitics: Conceptual Continuity in Complex Systems*, Yale University Press, New Haven, 1998, p. 1.

> human nature than mathematical models of the brain, or the theories of cognitive psychology. An engagement with the arts should not be a luxury in which we indulge after 'work,' it should be intertwined with our work. Faced with the complexities of life we all have to be artists in some sense of the word.[234]

It is here that intuition can be seen to undergo a regenerative process, assisting in restoring imaginative processes to understanding the international system.[235] Historians may well claim that they have always understood that the nature of what is being studied is contingent and never categorical.[236] However, missed by many historians is that, at a general level, they have always adhered to 'a kind of theory' without ever realizing the commitment.[237] Quite a different interpretive turn is possible. As Rosenau has asserted, 'inference and interpretation'[238] are now able to, unashamedly, return to research programmes within international relations. By accepting non-linearity, the anti-reductionist and the unpredictable nature of the world, it becomes possible to construe an idea of what a theory of international emergence might look like. Rosenau took tentative steps down this path, in his postscript for *Distant Proximities,* when he wrote that 'I now tend to avoid the word *international* and refer instead to *world affairs*',[239] questioning the certainty all too often enshrined in the state. Of importance to note here, however, is the realisation that science does not provide concrete answers in respect to social enquiry, yet neither should it be demonised as it (if it can be singularised) offers insight that is open to intuitive interpretation. Knowing nothing of non-linear approaches, Bull captured a truth of what science offered to the study of international relations:

> A more likely future for the theory of international politics is that it will remain indefinitely in the philosophical stage of constant debate about fundamentals; that the works of the new scientific

[234] Cilliers, 'What can we Learn From a Theory of Complexity?', p. 32.
[235] Kavalski makes a similar claim, see 'Emergence of Complex International Relations Theory', pp. 447, 451.
[236] Gaddis, 'In Defence of Particular Generalizations', p. 312.
[237] ibid., p. 303.
[238] Rosenau, *Turbulence in World Politics*, p. 27.
[239] Rosenau, *Distant Proximities*, p. 410.

> theorists will not prove to be solid substructure on which the next generation will build, but rather that those of them that survive at all will take their place alongside earlier works as partial uncertain guides to an essentially intractable subject; and that successive thinkers, while learning what they can from what has gone before, will continue to feel impelled to build their own houses of theory from the foundations up.[240]

Foundations that allow for, and accept, change, continuity, and, importantly, unpredictability offer a more substantive and flexible scientific base than the positivist social science he was critiquing. Here too lies a link with constructivism, as constant dialogue and exchange between structure and agent can be interpreted via an alternative meta-theoretical base. One scholar wryly referred to complexity theory as 'a new rationality that preserves unknowns', but he was closer to mark when, noting its 'hermeneutical indeterminacy', he suggested that it opens the door to narrative, interpretation and intuition.[241] With this in mind, it is constitutive theories that offer a closer understanding of international affairs, and they do so in a way 'that cannot be reduced to mechanical causation'.[242]

It is at this point that social scientists have to realize that a paradigm shift within the 'mature' sciences has occurred, and some time ago in fact. Understanding the social sphere is a skill. To acquire it, as Vico argued in *The New Science*, is to understand that 'man' himself creates the world:

> …in the night of thick darkness enveloping the earliest antiquity, so remote from ourselves, there shines the eternal and never failing light of a truth beyond all question: that this world of civil society has certainly been made by men, and that its principle can and must therefore be found within the modifications of our own human mind. Whoever reflects on this cannot but marvel that the philosophers should have bent all their energies to the studies of nature, which, since God made it, He alone knows; and that they should have neglected the study of the world of nations

[240] Bull, 'International Theory: The Case for a Classical Approach', pp. 369-70
[241] Stewart, 'Complexity Theories, Social Theories', pp. 323, 344, 350.
[242] Wendt, 'Why a World State is Inevitable', p. 495.

> or civil world, which, since men had made it, men could come to know.[243]

There is no scientific envy, nor any social determinism, in Vico's argument. Furthermore, there is no unrestrained relativism, nor is it a case of anything goes. There is only informed interpretation and intuition within parameters of shared, yet bounded, understanding. What is 'out there' is defined by what is 'in here', with the same holding true in reverse. Released must be positivist assumptions of the Newtonian worldview. It is a paradigm that has informed and influenced much within the social sciences, and, as has been shown, this is especially true of the dominant theories within IR. Theories that have pressed that certainty and additive conjecture offered the best route forward, while holding the belief that intersubjective relationships were of little relevance, need to be re-evaluated. A significant tidal shift has occurred; the world may no longer be solvable but it is interpretable. It is also full of surprises.

[243] Vico, *The New Science*, p. 96, sec. III, para. 331. See also Berlin, *Against the Current*, p. 106 and Prigogine and Stengers, *Order Out of Chaos*, p. 4.

Conclusion

Complexity theory has the potential to assist in reshaping the theoretical foundations of international relations. Its strength lies not in strict methodological applications, but in allowing a reinterpretation of how we think about the world. Consequently, care needs to be taken when appropriating the ideas. Scientific legitimacy is too easily granted to the social sciences because a pedigree with the natural sciences is established or *shown* to exist. However, this is a conversation that occurs in two directions. Just as social scientists need to be careful and respectful of the ideas they encounter when stepping into the scientific territory, so too should the natural scientist when entering the social sciences and the humanities. These guardians of the 'mature' and 'normal sciences'[1] need to develop an awareness as to the paradigmatic impact that their work, in a cultural sense, can have. The presuppositions that define dominant worldviews are reared

[1] Kuhn, *The Structure of Scientific Revolutions*, esp. ch. 1 and 2.

and supported on the perceived legitimacy of their words.[2] Given the rise to prominence of non-linear sciences in recent years, complexity theorists must develop a more astute appreciation of this. Yet scientists, particularly those looking at the grand sweep or a panoramic vision of the world, commonly display a keenness to 'unconceal' correlations and possible parallels with social systems and human society in general.

Seemingly unaware of the dangers involved in attaching the scientific certainty label, Stuart Kauffman is quite comfortable stepping into the social-political realm. This is evident when he expressed similarities and possible comparisons, devoid of any normative considerations, between notions of democracy, pluralism, and phase transitions.[3] However, at the same time, he clumsily steps into the realm of political theory, contending that his idea of patches adequately reflects a functioning modern democracy, but also suggesting, with hints of Fukuyama, that the liberal democratic mode of government is 'utterly natural'.[4] Ironically, he chastises James Mill, from an earlier period, of 'deducing the optimally familiar' as the highest form of representative government,[5] but he then cites the US constitutional model as his ultimate position.[6] Yet, whilst singing the praise of the US constitution, which itself was created and driven by the Enlightenment thought of Newton and Locke, Kauffman belatedly draws the reader's attention to the idea that 'our theory of democracy [in the singular] takes little account of the

---

[2] As Philip argues in respect to the appropriation of evolutionary theory, 'We cannot merely "tack on" these developments to our existing orthodox framework, as the principles discussed above represent a different *Gestalt* from which underlies our orthodox framework. Recognition of this difference in *Gestalt* is of paramount importance. Much research today is promoted under the rubric of "evolutionary thinking", yet the vast majority of this research fails to embrace adequately the spirit of the institutional/social mode of analysis, remaining instead within the cloak of "pseudo-physics" by stripping the evolutionary notions of their very social character', Philip, 'Foundation for Evolutionary Economics?', p. 21. Moreover, much care is needed when acquiring theoretical tools from the hard and natural sciences. The Spencarian social Darwinists that emerged during the nineteenth century act as a warning when transferring ideas and metaphors from sciences. What must be avoided is determinist conjecture that can occur when science is utilised to explain social phenomena. Gell-Mann, *The Quark and the Jaguar*, pp. 365-66.

[3] Kauffman, *At Home in the Universe*, p. 28.

[4] ibid., p. 271.

[5] For James Mill, the English philosopher, political theorist, economist and father of John Stuart Mill, the 'optimally familiar' was a constitutional monarchy that bore a similarity to the representative government of England from his very own period. ibid., pp. 270-1

[6] ibid.

unfolding, evolving nature of cultures, economies, and societies'.[7] Ideas are important. They establish how knowledge is filtered. But the material is similarly important, as it is what knowledge fixes onto. Yet, empiricism alone cannot explain the world, and ideas should never reach a linear-inspired endpoint. A constant *dialectic* plays out, and the world and the ideas that emerge to explain it evolve through time and space. Kauffman, as a complexity theorist, should have been acutely aware of this before he attempted fix political institutions upon a scientific bedrock.

What must be avoided is recreating a scientific theory of international relations that merely regurgitates isomorphic similarities, as this will be of the greatest hindrance to those that see the benefits to a non-linear understanding. As Earnest and Rosenau point out, there is a danger of slipping into irrelevancy by relying on '[t]he simulative methods of complexity' as it runs the risk of 'obfuscating important assumptions made by complexity researchers about actors and authority in global politics today'.[8] How communities are grouped and points of demarcation form from the local to the global needs to be understood, not by attempting to recreate the experiments of scientists, but by understanding how this new theoretical terrain might influence our parameters of understanding. Re-imagining the possibilities, the importance of the Gestalt switch-flicking[9] and allowing social theories to be influenced by an alternative paradigm, is where the greatest rewards await the theorist of international relations.

The Promise of Paradigms?

Paradigms have been a recurring theme throughout this thesis. It has been argued that at the meta-theoretical level a shift needs to occur. Within the literature, the term is used flippantly and with little regard to how its use was originally envisaged. For instance, one International Relations scholar had clearly misunderstood Kuhn when he wrote of the latter's argument '…that paradigms

[7] ibid., p. 299.
[8] Earnest and Rosenau, 'Signifying Nothing?', p. 157.
[9] Kuhn, *The Structure of Scientific Revolutions*, pp. 121-2.

cannot be changed, they can only die, [Kuhn] certainly did not have international relations in mind'.[10] The study of international relations is not a hard science, suggesting that the incommensurability of paradigms can be deflected and the capacity to develop an ontological depth exists. Patomäki and Wight are closer to the mark here when they state that:

> Although superficially a liberating position, Kuhn's thesis quickly legitimates a stagnant conservatism' for the study of IR … Given the complexity and open nature of the social world, however, it is hardly possible that one paradigm could ever dominate. Taking a complex social ontology seriously requires a commitment to a multi-paradigmatic approach.[11]

The idea of 'a complex social ontology' is important, and this is why much has been made in the thesis of the mind of the artists, with the point being to emphasise how a great deal of understanding is an intuitive process that has an appreciation for the irreducibility of phenomena. Patomäki and Wight's conceptualisation of the use of paradigms continues what equates to a near-tradition of attempting to insert Kuhn directly into the social sciences. However, the sentiment of what they write can be reconciled with the central argument that multiple understandings emerge from foundations, and this occurs without giving up on a notion of an external reality.

This is what this thesis has argued. It starts with the mind of the scientist that has dominated how the world is understood. It traversed how the conceptualization of a linear, predictable and universal order emerged triumphantly from the Scientific Revolution and the Enlightenment. The first chapter tracked the progress of this Newtonian worldview, and how it ascribed significance *inter alia* to the positivism of the nineteenth century. Although the more explicit claims, which in some

[10] Ernst-Otto Czempiel, 'Internationalizing Politics: Some Answers to the Question of Who Does What to Whom' in Ernst-Otto Czempiel and James Rosenau, eds, *Global Changes and Theoretical Challenges: Approaches to World Politics for the 1990s*, Lexington Books, Lexington, 1989, p. 117.

[11] Patomäki and Wight, 'After Postpositivism?', p. 226. See also Stefano Guzzini, 'Structural Power: The Limits of Neorealist Power Analysis', *International Organisation*, vol. 47, no. 3, 1993, pp. 446-7.

instances attached to specific research programmes,[12] had abated in the latter parts of twentieth century the implicit and insidious effects of this scientific paradigm continued to influence social thought. Of course, there were objectors. Critical theory, the domain of post-modernism and post-structuralism, as a reflexive knee-jerk reaction formed one of the substantial fronts in the attack on the dominance of the science of the Enlightenment. But any such attack is built in *opposition*, meaning its significance and, indeed, existence, is predicated on the presuppositions of the former. Earlier, in what is now referred to as the counter-Enlightenment, objections were also raised. It is difficult to categorise counter-Enlightenment thinkers as a single homogenous group as they represent an *ad hoc* after-the-fact union. Yet, the main objections can be said to be the abstraction, reduction and the mathematisation of thought; 'boiling down' the world to uncover simple unifying rules. Vico, prominently, lamented the mathematisation of knowledge, the creation of mathematical social facts. For others, it was the divorce between reason and imagination that attracted considerable ire. Blake and Goya were particularly scathing of this division.

Imagination, as argued in Chapter Two, is an inescapable element of human understanding, and this simply cannot be divorced from reason. The desire to construct an ordered world pushed the importance of imagination to one side. The desire for order and linearity was imbued by the dominant scientific paradigm, driving the wedge of traditional science between the rational and the irrational. A neat, orderly and Newtonian imagination emerged under the auspices of the dominant paradigm. Nowhere is this more prevalent than in the desire to purge chaos, or, at the very least, to depict it as a great evil. Chaos was all too often, and indeed still is, depicted as a state of affairs that order and regulatory linear theories sought, and seek, to purge. Yet, by the late nineteenth and earlier twentieth century, a number of the scientists were charting new territories and

[12] For instance, see the behaviouralist tradition in IR, positivist economics, logical or neo-positivism in philosophy, or the legal positivist tradition. On the influence of legal positivism upon IR see Brian Schmidt, *The Political Discourse of Anarchy: A Disciplinary History of International Relations*, State University of New York Press, Albany, 1998, pp. 103-9.

their incremental findings began to bear weight upon the dominant paradigm. The likes of Poincaré, Einstein, and Heisenberg were bringing forth new ideas that were not always reconcilable with the old Newtonian understanding. The single largest distinction that emerged was the uncertainty that was present in the world. Clockwork universes and billiard-ball models soon began to break down. God, it appeared, did enjoy playing with dice.[13] However, mainstream theories in the social sciences, for the most part, held firm. The challenge to a paradigm is often generational, yet for the less mature sciences the need for change is not necessarily driven with the same intensity, as incommensurability in the social sciences only properly occurs at the meta-theoretical level.

Notice was taken, however, and a small and dedicated following arose very quickly in response to a new theory that embraced disorder and uncertainty. Chaos theory captured the scientific and social imagination. It created images that appealed to the mathematician and the artist alike. It claimed to reveal how nature, in all its roughness, really worked.[14] There existed an excitement, as the division between scientific endeavour and artistic intuition was, finally, released from the Newtonian grasp that had for so long separated them. However, in time, its usefulness as a theory to explain both social and scientific phenomena was exposed as being limited. Its randomness within a deterministic framework meant that evolution and emergence was of little consequence, and the self-similarity of agents was often much too homogenising. Even with all this in mind, its importance should not be understated, as it breached disciplinary barriers and added weight to research programmes that sought non-linear alternatives to understanding. From these beginnings arose the loose confederation of

[13] Of course, it is widely cited that Einstein felt that God, or the 'old one' did not play dice. However, his belief here needs to be understood in context, as it reflects a disbelief toward the kind of statistical laws that chaos and complexity theory have challenged. Einstein once wrote (in a letter to James Franck) that he could 'imagine that God created a world without any laws: a chaos in short. But the notion that statistical laws are final and that God draws a lot, is highly unsympathetic to me'. Yehuda Elkana, 'The Myth of Simplicity' in Gerald Holton and Yehuda Elkana, eds, *Albert Einstein: Historical and Cultural Perspectives*, Princeton University Press, Princeton, 1982, p. 239. Indeed, for Einstein intuition should always play a central role. ibid. p. 221. See also Paul H. Carr, 'Does God Play Dice? Insights From the Fractal Geometry of Nature', *Zygon*, vol. 39, no. 4, 2004, pp. 933-40.

[14] See Mandelbrot, 'Fractals and an Art', p. 21.

approaches that would become known as the complexity sciences, from which, with a loose and flexible agreement on a set of core ideas, emerged complexity theory.

With complexity science research institutions[15] springing up with a degree of regularity, the non-linear turn was taking effect. The third chapter outlined the core components of this research. Mainstays had developed. Sensitivity to initial conditions denied the power of certainty and prediction for those who study the nature of relationships in systems. Self-organisation moved away from simple equilibrium-finding invisible hand conjecture, to it being appreciated as a process that pushes adaptive communities around points of attraction. Indeed, even the obscure notion of phase transitions allow social scientists to imagine how patterned systems are situated between halting and ordered dimensions, on the one hand, and noisy and chaotic dimensions, on the other. Moreover, the openness of non-linear systems has been embraced, meaning that they are understood as being of high energy[16] and operate far-from-equilibrium, rejecting any notional point of stasis. Furthermore, multiple equilibria are accepted, as is the adaptive nature of agents and their ability to, often unknowingly, reinforce dominant patterns, or effect change in a non-additive fashion, thereby unsettling traditional notions of cause and effect; all of which culminates in the idea of overlapping and nested complex adaptive systems coexisting, re-enforcing and reinventing each other. It would appear, therefore, that God prefers to play with *loaded* dice.[17] These ideas supported the introduction of six presuppositions at the beginning of the third chapter, so as to represent complexity theory as an alternative scientific paradigm that can inform the social sciences. At the meta-theoretical level, this permits alternative ontological and epistemological assumptions to take root. The accepted fundamentals that constitute complexity theory allows, it has been argued, for the concept of emergence to become a central concept that captures why order will *always* emerge in a complex system.

[15] Some attracting top scientific minds, including Nobel laureates.
[16] The loss of energy, that is the entropic nature of these systems, is what makes them high energy.
[17] Gleick, *Chaos*, p. 314; Carr, 'Does God Play Dice?', pp. 933-40.

This meta-theoretical re-imagination has the possibility, it has been argued, to impact upon how theories of international relations might be conceptualised. The fourth and fifth chapters outlined how the Newtonian worldview seeped into International Relations theory. This worldview is responsible for the preoccupation with order, anarchy and a rudimentary understanding of power, and, with that, the continuation of the desire to create theories that display order and neatness via simplification and reductionism. Further, it was argued that the Newtonian paradigm, however implicitly, is transferred via an economic ontological understanding, economics, of course, being the most Newtonian and scientific of the social sciences. The rationalist twins of realism and liberalism, and their neo- variants, draw on the rational choice of this 'economic man' to present simplified and cut-down versions of social existence. From these theories, what emerged was a system of maximisers whose self-interested desires 'balanced' the international order. States are argued to be the main players, and, furthermore, they are a-historical and amoral. Mainstream International Relations theory rejected chaos and embraced a linear order that constructed power in terms of basic capabilities, constantly searching for a theory of natural equilibrium. Complexity theory, incorporated at a meta-theoretical level, challenges these notions. It allows for a more fluid appreciation of agent and structure, with each informing the other. The notion of anarchy can be understood as being contextual. Constitutive theories, normative and constructivist[18] approaches are shown to easily meld with the presuppositions laid out in Chapter Three. However, it has always been asserted throughout the thesis that a non-linear understanding will support a breadth of International Relations theories, so long as these theories are able to surrender positivist assumptions of linearity, reductionism, predictability from additive conjecture, and the belief that intersubjective relationships are of little relevance. Of course, such an absorption by some theories might well recast them to point of no longer reflecting their own traditional core assumptions.

[18] This could be extended to include English School approaches.

Yet, the defence of theory is important, otherwise irrelevancy lurks as each popular whim will recast and challenge what might be a perfectly good theory. However, the point still stands: the defence of theory should not be about taking to the barricades to defend a long-held theory because of a miscast sense of loyalty or allegiance. Instead, theorists need to be certain that theirs is built on solid, or in this case of complexity theory, *fluid* foundations. If these non-linear lessons are absorbed, then, at a general level, the politics of world affairs can be understood as being of multiple equilibria and of multiple complex adaptive systems overlapping and nested around stable points of attraction that are neither permanent nor fixed. The weight of the thesis supports the conclusion that an alternative point of departure now exists when considering how to utilise International Relations theory. What role, then, might theory hold in a world deemed so unpredictable and contingent?

Predictions and Possibilities?

Self-organisation reveals that the global system evolves without any outside interference, and that no agent, not even a hegemon, can dictate the appearance of its final form. The international system should be understood as an emergent process, where the properties 'are "unpredictable" and "non-additive" results of complex processes'.[19] The continual feedback that rearranges boundaries and the knowledge and intent of agents denies the possibility of such a final form. So what, then, does complexity theory offer to the study of international relations? First and foremost, complexity offers uncertainty; it does not offer concrete answers. It provides space for alternative theories that do not, for example, hope to prove end results, or, alternatively, to devise a system of changing parts. For too long, as Gaddis has argued, International Relations theorists have used:

> the methods of classical science when they conduct their investigations exclusively along a behavioural, structural, or – within the evolutionary approach – a linear or cyclical axis of analysis. They are excluding other variables and controlling

[19] C. Lloyd Morgan quoted in Hodgson, 'Economics and the Return to Mecca', p. 405..

> conditions in order to produce theories from which they can forecast events. They know that if they do not impose such exclusions and controls, complications will quickly overwhelm their calculations, and predictability will suffer. Exercises of this kind can yield useful insights: so too can simple experiments in freshman physics. But generalizations of this kind perform badly when applied to the real world, which functions along behavioural, structural, and evolutionary axes *simultaneously*. The generation of theory – at least in the traditional scientific method – requires departures from reality; if forecasts derived from theory are to succeed, however, they must also account for reality.[20]

If complexity theory is to inform approaches, then it must be accepted that any level of prediction will only be possible as a generalisation, with accuracy obviously tied to a shortening or lengthening time horizon. Since the boundaries of a system are not easily defined, it is not plausible to suggest that all considerations and variables can be taken into account. Sensitivity to initial conditions illustrates that knowing what is important, and what is not, can be difficult to discern.[21] In essence, with an appropriate understanding, complexity theory offers a 'nuanced approach' that can possibly curb International Relations theorists of their 'panacean impulses.'[22] The possibility that is being presented, therefore, is a headlight that can offer some form of illumination,[23] coupled with an awareness as to the limited nature of human understanding and knowledge.[24] In a post-Newtonian world, complexity theory presents a means to embrace uncertainty instead of reverting to the traditional methods of pigeon-holing the

---

[20] Gaddis, 'International Relations Theory', p. 55. Prior to this point Gaddis acknowledges the dominance of the Newtonian paradigm, also implicitly underscoring Kuhnian notions of paradigm defence, when he states 'The classical scientific method had been to generate laws, and hence predictions, from experiments that limited the number of variables involved and that controlled – sometimes quite arbitrarily – the conditions within which they operated. Newton's laws of motion, for example, assumed perfectly smooth balls rolling down frictionless inclines with no air resistance, a condition never actually encountered in the real world. Generations of students were taught that feathers and stones fall to earth at the same speed, despite the fact that they never really do. Predictability was achieved by removing the object being studied from its origins and its surroundings: one gained a vision of the future by shutting one's eyes to the past and present. But the more one observed past and present, the more Heisenberg's principle came into play, and the less confidence one could have in the forecasts made'. ibid., p. 54.

[21] Cilliers, 'What Can We Learn From a Theory of Complexity', p. 28.

[22] Rosenau, 'Many Damn Things Simultaneously', p. 82.

[23] Gell-Mann, *The Quark and the Jaguar*, p. 366.

[24] Cilliers, 'What Can We Learn From a Theory of Complexity', p. 32.

facets of a system. Holland looks to the weather for an analogy to promote usefulness of complexity noting that:

> The weather never settles down. It never repeats itself exactly. It's essentially unpredictable a week or so in advance. And yet we can comprehend and explain almost everything we see up there. We can identify features such as weather fronts, jet streams and high-pressure systems. We can understand their dynamics.[25]

Holland considers the possibility that the sixty per cent accuracy of meteorology could possibly be transferred to a complex adaptive system.[26] It is unlikely that such accurate short-term predictions are possible for social systems, due to their overlapping nature, coupled with the diversity and adaptability of agents. Clouds simply don't learn, people do. Yet complexity-inspired approaches will, at the very least, provide a different way of understanding the changes and increasing complexity of the international system. For instance, failing to factor in feedback means that taking a path, say, to the theme of deforestation 'without knowing how the overall system will adapt' can 'set in motion a train of events that will likely come back and form a different pattern for us to adjust to'.[27] As Hedley Bull noted:

> The search for conclusions that can be presented as 'solutions' or 'practical advice' is a corrupting element in the contemporary study of world politics, which properly understood is an intellectual activity and not a practical one. Such conclusions are advanced less because there is any solid basis for them than because there is a demand for them which it is profitable to satisfy. The fact is that while there is a great desire to know what the future of world politics will bring, and also to know how we should behave in it, we have to grope about in the dark with respect to the one as much as with respect to the other. It is better to recognise that we are in darkness than to pretend that we can see light.[28]

---

[25] Holland quoted in Bronk, *Progress and the Invisible Hand:*, p.197. See also Holland, *Hidden Order*, pp. 168-69.
[26] Holland, *Hidden Order*, p.168. See also Rosenau, , 'Many Damn Things Simultaneously', p 93.
[27] Arthur quoted in Waldrop, *Complexity*, p. 333.
[28] Bull, *The Anarchical Society*, p.?

In the introduction to this thesis, a closed system was analogised as being akin to car maintenance. Within an open system there are no metaphorical carburettors that can be taken apart and explained in their entirety without any consideration of their interdependency to the rest of the vehicle. Carburettors do not have to deal with semi-autonomous pistons, and any car operating far-from-equilibrium is most certainly in need of a service. With this in mind, complexity theory teaches that any mechanistic analogy, or an affirmation to an actual reality that posits that a system can be balanced on an idealised point of equilibrium, will fail. The international system is best thought of as groups of multiple agents that all aggregate at different levels, across time and space. They form the equivalent of synaptic relationships: some connections are weak, others strong. This means that these various agents are 'bound' within an open system by intersubjective relationships that reinform and reconstitute each other. The notions of sensitivity to initial conditions (which can result in global reverberations), and feedback (which can result in path dependence away from the 'optimal' position), underscore the non-linearity of the system. This ultimately results in appreciating world affairs as a series of overlapping and interconnected self-organising systems. Agency is not stripped away. Indeed, the interactions of the agents that occasionally break with routine allow new structures to form,[29] with both the system and agents becoming a part of the endless feedback process. To be any more specific than in producing such generalisations requires a transference of the ideas from the non-linear paradigm to those International Relations theories that have the scope to accommodate the lessons of complexity. International Relations theorists who wish to pursue this path have the difficult task of attributing the significance of interconnected parts; they have to partake in the process of delineating the international world, deeming what elements constitute parts, and declaring wholes and aggregates. They must determine which interactions are to be deemed to be of greater or of more central significance. Emergence *must* be central to conjecture of this nature. All of this occurs under the watchful eye of the complexity turn, in its rightful place as a meta-theoretical commitment.

[29] See Rosenau, *The Study of World Politics*, p. 111.

A Complex Theory of International Politics?

Broadly speaking, any theory of international politics that absorbs the lessons of complexity would almost certainly have to accommodate the interactions of multiple agents around the world that have created a self-reinforcing global system. Chapter Five, in particular, isolated the structure-agent debate as a means of appreciating the constitutive nature of international relations. This is a basic acknowledgement that:

> The agency/structure debate might have provided the needed wrecking ball. Asking what agents and structures actually *are* is a healthy subversive question, potentially opening up consideration of a wide variety of politics and domains. Unfortunately, the answer has been limited largely to the familiar question of the relationship of domestic agents and states. We repeat: describing the world as 'anarchic' fails to capture, not only the choice of states, but also the routine 'governance' exercised by a galaxy of polities, some inside state sovereign frontiers, some outside, and still others transcending lines on a territorial map.[30]

From the wreckage of the dominant discourses of International Relations theory arise the possibilities of a complex theory of international politics or a theory of international emergence. Here, the world polity is an emergent phenomenon. Again, broadly, any theory of this kind, which would be formed in conjunction with existing theories, would have to engage with a multiplicity of factors. Conceivably, International Relations theory-making would need to acknowledge certain developments, as, for instance, the interdependency that exists between states, and how this has slowly increased over the centuries. The argument could then be made that this interdependency and *intersubjectivity* increased exponentially in the twentieth century, particularly with the end of the Cold War; in itself a result of a movement away from a relatively closed system the world experienced during the bipolar standoff, to that of the most open. This, in turn,

[30] Ferguson and Mansbach, *Remapping Global Politics*, pp. 95-6.

could be *interpreted* as releasing the leviathan of globalisation, an international emergent network that can be understood as taking hold across multiple levels and influencing various overlapping and nested complex adaptive systems. Positive feedback effects upon highly networked non-linear systems would similarly need to be integrated to assist in explaining how the process of globalisation has increased exponentially. Depending on one's theoretical outlook, it might then be argued that positive feedback (or increasing returns) has locked in a path that supports the continuation of globalisation, however that might be defined.

Of course, any such theory would need to take disruptions into consideration. Sudden and unpredictable punctuation of equilibria would drive the systems to new points of attraction. Contrapuntally, some level of structural integrity would need to be reflected by the theory, with even the dramatic events of September 11 only momentarily slowing economic activity, whilst arguably increasing other factors like migration flows, or more ambiguous concepts like global consciousness. This change and continuity, at a material level alone, would be need to incorporate the effects of non-linear dynamism upon global communication, trade, media, finance, delivery systems and a multitude of other aspects that will irrespectively feed-back and reinforce the process. Likewise, the proliferation of supranational organisations, multinational companies and non-government organisations is likely to continue when world politics is examined through this lens. As international politics continues to find more and differing types of order, and the world organises into more and more complex forms, mitigated occasionally by dramatic shifts, Wendt's world becomes foreseeable, just not teleological.[31] As Eric Hobsbawn has stated, globalisation should be understood as an historical process that has sped up in recent times, but it is a continual, constant and permanent transformative process.[32] Complexity-inspired

---

[31] In reference to a preconceived political structure.

[32] Eric Hobsbawm, *The New Century: In conversation with Antonio Polito*, Trans. Allen Cameron, Abacus, London, 2000, p. 61. The permanency, in the context of this thesis, should be interpreted as being irreversible.

approaches to how world order is understood can offer this manner of vision of the global. Yet, it must not be forgotten that:

> global complexity is not simply anarchic disorder. There are many pockets of ordering within this overall patterning of disorder, processes involving a particular performing of the global and operating over multiple time-space with various feedback processes. Such pockets of ordering include various networks, fluids and government mechanisms. These different pockets of order develop *parallel* concepts and processes of what we call the global. At different levels there are what we may term 'global fractals', the irregular but strangely similar shapes that are found at very different scales across the world, from the household say to the UN.[33]

Within this framework, it would then be possible to argue, for example, that the role of the state remains central, although not permanently so. The notion of sovereignty can be interpreted as having evolved as states have had to evolve, with the more successful states being adaptive. Previously, how international networks and interdependence have been thought to function has been in the domain of, and held ransom by, economic theories cut from Newtonian cloth; indeed, they represented the hardest and most precisely mathematically devised social science. Offered instead are non-linear interpretations that place the international system in a space that is neither ordered nor chaotic, and a space that occurs at multiple levels. Continuities within this space would need to be integrated into any complex theory, or theories, of international relations, as stable patterns do emerge between, and across, cultures and political divides. Vico, very much a man of his times, recognised this when he argued that no matter how 'crude and savage', extravagant ceremonies exist in all cultures, irrespective of separation by time and distance. Suggested, then, is the universality of these principles.[34] However, it would not be a universalism of Newtonian proportions,

---

[33] Urry, *Global Complexity*, p. 102.
[34] Vico, *The New Science*, p. 97, sec. III, para. 332. However, Vico does not escape creating universal axioms and principles of human society be they, yet still bound by his time and the inherent privileging of Western ontological perspectives, that 'all nations' whether barbarous or civilized are contained by these principles. Vico writes: 'Now, since this world of nations has been made by men, let us see in what institutions all men agree an always have agreed. For these institutions will be able to give us the universal and eternal principles

an axiomatic principle to build from. Again, this would be to accept the dominance of certain points of attraction, shaped by boundary considerations. This is the world of continual emergence, increasing complexity, and a system that is more than the sum of its parts.

(such as every science must have) on which all nations were founded and still preserve themselves.' ibid., p. 97, sec. III, para. 332.The three principles that Vico considers to be an intrinsic part of all 'nations' are religion, marriage, and burying the dead. ibid., p. 97, sec. III, para. 333.

Bibliography

'Sir Isaac Newton', *Westminster Abbey: From 1605 to Today*, http://www.westminster-abbey.org/history-research/monuments-gravestones/people/12186, (accessed 14/06/2007).

'The RMA Debate' website, 'Network Centric Warfare' at http://www.comw.org/rma/fulltext/netcentwar.html, (accessed 12/02/2008).

Ackerman, Frank, 'Still dead after all these years: interpreting the failure of general equilibrium theory', *Journal of Economic Methodology*, vol. 9, no. 2, 2002, pp. 119-39.

Adler, Emanuel, 'Constructivism and International Relations', in Walter Carlsnaes, Thomas Risse and Beth A. Simmons, eds, *The Handbook of International Relations*, Sage, Thousand Oaks, 2002.

Ahnert, Thomas, 'Newtonianism in early Enlightenment Germany, c. 1720 to 1750: Metaphysics and the Critique of Dogmatic Philosophy', *Studies in History and Philosophy of Science*, vol. 35, no. 3, 2004, pp. 471-91.

Albert, David S. and Thomas J. Czerwinski, (Eds.), *Complexity, Global Politics and World Affairs*, University Press of the Pacific, Honolulu, 1997.

Alker, Jr., Hayward R. and Thomas J Biersteker, 'The Dialectics of World Order: Notes for a Future Archaeologist of International Savoir Faire', *International Studies Quarterly*, vol. 28, no. 2, 1984, pp. 121-42.

Alverz, Jose E., 'The WTO as Linkage Machine', *The American Journal of International Law*, vol. 9, no. 1, 2002, pp. 146-58.

Anderson, Benedict, *Language and Power: Exploring Political Cultures in Indonesia*, Cornell University Press, Ithaca and London, 1990.

___________, *Imagined Communities: Reflections on the Origin and Spread of Nationalism*, Rev. ed., Verso, London and New York, 2006.

Anderson, Philip W., 'Physics: The Opening to Complexity', *Proceedings of the National Academy of Sciences of the United States of America*, vol. 92, no. 15, 1995, pp. 6653-4.

Appleby, Joyce, Lynn Hunt and Margaret Jacob, *Telling the Truth About History*, W. W. Norton & Co., New York 1994.

Arkin, William M., 'A New Mindset for Warfare', *Washington Post*, September 22, 2001, www.washingtonpost.com/ac2/wp-dyn/A8672-2001Sep22, (accessed 23/09/2001).

Arquilla, John and David F. Ronfeldt, 'What Next for Networks and Netwars?', in Arquilla, John and Ronfeldt, David F., eds, *Networks and Netwars: The Future of Terror, Crime, and Militancy*, RAND, Santa Monica, 2001.

___________, 'Netwar Revisited: The Fight for the Future Continues', *Low Intensity Conflict and Law Enforcement*, vol. 11, no. 2 & 3, 2002, pp. 178-89.

___________, 'The Advent of Netwar (Revisited)'in Arquilla, John and Ronfeldt, David F., eds, *Networks and Netwars: The Future of Terror, Crime, and Militancy*, RAND, Santa Monica, 2001.

___________, *Networks and Netwars: The Future of Terror, Crime, and Militancy*, RAND, Santa Monica, 2001.

Arthur, W. Brian, 'Complexity and the Economy', *Science*, vol. 284, no. 5411, April 2, 1999, p. 107.

___________, 'Complexity in Economic Theory: Inductive Reasoning and Bounded Rationality', *American Economic Review*, Vol. 84, No. 2, 1994, pp. 406-11.

___________, 'Positive Feedbacks in the Economy', *The McKinsey Quarterly*, no. 1, 1994, pp. 81-95.

Ashley, Richard K., 'The Poverty of Neorealism', *International Organization*, vol. 38, no. 2, 1984, pp. 225-86.

Aubin, David and Amy Dahan Dalmedico, 'Writing the History of Dynamical Systems and Chaos: Longue Dureé and Revolution, Disciplines and Cultures', *Historia Mathmatica*, vol. 29, 2002, pp. 273-339.

Axelrod, Robert, *The Complexity of Cooperation: Agent-Based Models of Conflict and Cooperation*, Princeton University Press, Princeton, 1997.

Axtmann, Roland, 'The State of the State: The Model of the Modern State and Its Contemporary Transformation', *International Political Science Review*, vol. 25, no. 3, 2004, pp. 259-79.

Azis, Iwan J., The Nonlinear General Equilibrium Impact of the Financial Crisis and the Downfall of Manufacturing', *The Developing Economies*, vol. 38, no. 4, 2000, pp. 518–46.

Bajpai, Kanti, 'Indian Conceptions of Order and Justice: Nehruvian, Gandhian and *Hindutva*, and Neo-Liberal', in Rosemary Foot, John Lewis Gaddis, and Andrew Hurrell, eds, *Order and Justice in International Relations*, Oxford University Press, Oxford, 2003.

Bak, Per, Chao Tang and Kurt Wiesenfeld, 'Self-Organized Critically', *Physical Review A*, vol. 38, no. 1, 1988, pp. 364-74.

Baker, Patrick, 'Chaos, Order and Sociological Theory', *Sociological Inquiry*, vo. 63, no. 2, 1993, pp. 123-49.

Baldwin, David A., 'Power and International Relations', in Walter Carlsnaes, Thomas Risse and Beth A. Simmons, eds, *The Handbook of International Relations*, Sage, Thousand Oaks, 2002.

Ball, Philip, *Critical Mass: How One Thing Leads to Another*, Arrow Books, London 2004.

Ball, Terence, 'From Paradigms to Research Programs: Towards a Post-Kuhnian Political Science', *American Journal of Political Science*, vol. 20, no. 1, 1976, pp. 151-77.

Bannister, Robert C., '"The Survival of the Fittest is Our Doctrine": History or Histrionics?' in John Offer, ed., *Herbert Spencer: Critical Assessments of Leading Sociologists*, vol. 2, Routledge, London, 1999.

Barber, Benjamin R., 'Beyond Jihad vs. McWorld: On Terrorism and the New Democratic Realism', *The Nation*, vol. 274, no. 2, 2002, pp. 11-15.

Barnes, Barry, 'Thomas Kuhn', in Skinner, Quentin, ed., *The Return of Grand Theory in the Human Sciences*, Cambridge University Press, Cambridge, 1985.

Barnsley, Michael, *Fractals Everywhere*, Academic Press, San Diego, 1988.

Barrow, John D., *Impossibility: The Limits of Science and the Science of Limits*, Vintage, London, 1999.

Barrow-Green, June, *Poincaré and the Three Body Problem*, American Mathematical Society and London Mathematical Society, Providence and London, 1997.

Bauman, Zygmunt, 'Sociology after the Holocaust', *The British Journal of Sociology*, vol. 39, no. 4, 1988, pp. 469-97.

Beauchamp, Tom and Alexander Rosenberg, *Hume and the Problem of Causation*, Oxford University Press, New York, 1981.

Beaumont, Roger, *War, Chaos and History*, Praeger, Westport and London, 1994.

Becker, Carl L., *The Heavenly City of the Eighteenth Century Philosophers*, Yale University Press, New Haven, 1932.

Becker, Karl-Heinz and Michael Dörfler, *Dynamical Systems and Fractals: Computer Graphics Experiments in Pascal*, trans. Ian Stewart, Cambridge University Press, Cambridge, 1989.

Beeson, Mark and Alexander J. Bellamy, 'Globalisation, Security and International Order After September 11', *Australian Journal of History and Politics*, vol. 49, no. 3, 2003, pp. 339-54.

Bell, Duncan, 'Beware of False Prophets: Biology, Human Nature and the Future of International Relations Theory', *International Affairs*, vol. 82, no. 3, 2006, pp. 493-510.

Benjafield, John G., 'Revisiting Wittgenstein on Köhler and Gestalt Psychology', *Journal of the History of the Behavioral Sciences*, vol. 44, no. 2, 2008, pp. 99–118.

Bergson, Henri, *Creative Evolution*, trans. Arthur Mitchell, Macmillan, London, 1911.

Berlekamp, Elwyn and Tom Rodgers, eds, *The Mathemagician and Pied Puzzler: A Collection in Tribute to Martin Gardner*, A K Peters, Wellesley, 1999.

Berlin, Isaiah, 'Divorce between the sciences and the humanities', in Henry Hardy and Roger Hausheer, eds, *The Proper Study of Mankind: An Anthology of Essays*, Farrar, Straus and Giroux, New York, 1997.

___________, 'The Origins of Cultural History: 'Geisteswissenschaft' and the Natural Sciences Vico versus Descartes', Second of three Gauss lectures given at Princeton in 1973. Available online Isaiah Berlin Virtual Library, http://berlin.wolf.ox.ac.uk/lists/nachlass/origins2.pdf (accessed 25/3/2006).

___________, *Against the Current: Essays on the History of Ideas*, The Hogarth Press, London, 1980.

___________, *The Age of Enlightenment: Selected, with Introduction and Commentary*, Mentor Books, New York, 1956.

Bhaskar, Roy and Tony Lawson, 'Introduction: Basic Texts and Developments' in Margaret Archer, Roy Bhaskar, Andrew Collier, Tony Lawson and Alan Norrie, eds, *Critical Realism: Essential Readings*, Routledge, London, 1998.

Bhaskar, Roy, 'Philosophy and Scientific Realism' in Margaret Archer, Roy Bhaskar, Andrew Collier, Tony Lawson and Alan Norrie, eds, *Critical Realism: Essential Readings*, Routledge, London, 1998.

Bieler, Andreas and Adam David Morton, 'The Gordian Knot of Agency—Structure in International Relations: A Neo-Gramscian Perspective', *European Journal of International Relations*, vol. 7, no. 1, 2001, pp. 5-35.

Biersteker, Thomas J., 'State, Sovereignty and Territory', in Walter Carlsnaes, Thomas Risse and Beth A. Simmons, eds, *The Handbook of International Relations*, Sage, Thousand Oaks, 2002.

Birchfield, Vicki 'Contesting the Hegemony of Market Ideology: Gramsci's 'Good Sense' and Polanyi's 'Double Movement', *Review of International Political Economy*, vol. 6, no. 1, 1999, pp. 27-54.

Blake, William, *Annotations to Sir Joshua Reynolds' Discourses*, (c. 1808)' in Eitner, Lorenz, *Neoclassicism and Romanticism 1750-1850*, vol. 1 (sources and documents in the history of art series), Prentice-Hall International, London, 1971.

___________, *Newton*, 1795/Circa 1805, Tate Collection, available at: http://www.tate.org.uk/servlet/ViewWork?cgroupid=999999961&workid=1122, (accessed 17/05/2006).

Boesche, Roger, 'Why Could Tocqueville Predict So Well?', *Political Theory*, vol. 11, no. 1, 1983, pp. 79-103.

Bossemaier, Terry R. J. and David E. Green, eds., *Complex Systems*, Cambridge University Press, Cambridge, 2000.

Bovil, Carl, *Fractal Geometry in Architecture and Design*, Birkhäuser, Boston, 1996.

Boylan T.A., and P.F. O'Gorman, 'Axiomisation and Formalism in Economics', *Journal of Economic Surveys*, vol. 21, no. 3, 2007, pp. 426-46.

Brenner, Neil, 'Beyond State-Centrism? Space, Territoriality, and Geographical Scale in Globalization Studies', *Theory and Society*, vol. 28, no. 1, 1999, pp. 39-78.

__________, 'Global Cities, Glocal States: Global City Formation and State Territorial Restructuring in Contemporary Europe', *Review of International Political Economy*, vol. 5, no. 1, 1998, pp. 1-37.

Brenner, Robert, 'The World Economy at the Turn of the Millennium Toward Boom or Crisis?', *Review of International Political Economy*, vol. 8, no. 1, 2001, pp. 6 – 44.

Briggs, John, *Fractals: The Patterns of Chaos: Discovering a New Aesthetic of Art Science and Nature*, Simon & Schuster, New York, 1992.

Brockliss, L.W.B., 'Aristotle, Descartes and the New Science: Natural philosophy at the University of Paris, 1600-1740, *Annals of Science*, vol. 38, no. 1, 1981 , pp. 33-69.

Brockman, John ed., *The Third Culture: Beyond the Scientific Revolution*, Simon & Schuster, 1995, http://www.edge.org/documents/ThirdCulture/d-Contents.html, (accessed 14/02/2006).

Bronk, Richard, *Progress and the Invisible Hand: The Philosophy and Economics of Human Advance*, Little, Brown and Company, London, 1998.

Browaeys, Marie-Joëlle and Walter Baets, 'Cultural Complexity: a New Epistemological Perspective', The Learning Organization, vol 10, no. 6, 2003, pp. 332-9.

Brown, Chris, 'On the Borders of (International) Political Theory', in O'Sullivan, Noel ed., *Political Theory in Transition*, Routledge, London, 2000.

Brown, Chris (with Kirsten Ailey), *Understanding International Relations*, 3rd ed., Palgrave Macmillan, New York, 2005.

Brown, Dan, *The Da Vinci Code*, Bantam, London, 2003.

Browning, Gary, Abigail Halcli and Frank Webster, eds., *Understanding Contemporary Society: Theories of the Present*, Sage Publications, London, 2000.

Brunk, Gregory G., 'Self-Organized Criticality: A New Theory of Political Behaviour and Some of Its Implications', *British Journal of Political Science*, vol. 31, no. 2, 2001, pp. 427-45.

Brunner, Ronald D., 'A Paradigm for Practice', *Policy Sciences*, vol. 39, no. 2, 2006, pp. 135-67

Buckley, Walter F., 'Society as a Complex Adaptive System', in Walter F. Buckley, ed., *Modern Systems Research for the Behavioural Scientist*, Aldine de Gruyter, Hawthorne, 1968.

Bull, Hedley, 'International Theory: The Case for a Classical Approach', *World Politics*, vol. 18, no. 3, 1966, pp. 361-77.

___________, *The Anarchical Society: A Study of Order in World Politics*, 2nd ed., MacMillan, London, 1995.

Bunk, Steve, 'The Institute Different', *The Scientist: The News Journal of the Life Sciences*, vol. 15, no. 4, 2001, p. 1.

Burke, Anthony, *In Fear of Security: Australia's Invasion Anxiety*, Pluto Press, Annandale, 2001.

Burr, Vivien, *An Introduction to Social Constructionism*, Routledge, London, 1995.

Burraston, Dave and Andrew Martin, 'Digital Behaviors and Generative Music', *Leonardo Electronic Almanac*, vol. 14 no. 7-8, 2006, http://leoalmanac.org/journal/Vol_14/lea_v14_n07-08/dburastonamartin.asp, (accessed 07/07/2007).

Burton, John W., *Conflict: Resolution and Provention*, Macmillan, Basingstoke, 1990.

___________, *World Society*, Cambridge University Press, Cambridge, 1972.

Bussanich, John, 'A Theoretical Interpretation of Hesiod's Chaos', *Classical Philology*, vol. 78, no. 3, 1983, pp?

Butterfield, Hebert, *International Conflict in the Twentieth Century: A Christian View*, Routledge and Kegan Paul, London, 1960.

___________, 'The Balance of Power' in Herbert Butterfield and Martin Wight, eds, *Diplomatic Investigations: Essays in the Theory of International Politics*, Allen and Unwin, London, 1966.

Buzan, Barry and Ole Wæver, *Regions and Powers: The Structure of International Security*, Cambridge University Press, Cambridge, 2003.

Byrne, David 'Complexity, Configuration and Cases', *Theory, Culture & Society*, vol. 22, no. 5, pp. 95-110.

___________, *Complexity Theory and the Social Sciences: An Introduction*, Routledge, London, 1998.

Caldwell, Bruce, 'Positivist Philosophy of Science and the Methodology of Economics', *Journal of Economic Issues*, vol. 14, no. 1, 1980, pp. 53-76.

Calinger, Ronald S., 'Frederick the Great and the Berlin Academy of Science (1740-1766), *Annals of Science*, vol. 24, no. 3, pp. 239-50.

Calude, Cristian S. and Michael A. Stay, 'From Heisenberg to Gödel via Chaitin', *International Journal of Theoretical Physics*, vol. 46, no. 8, 2007, pp. 1053-65.

Caporaso, James A., 'Microeconomics and International Political Economy: The Neoclassical Approach to Institutions' in Ernst-Otto Czempiel and James Rosenau, eds, *Global Changes and Theoretical Challenges: Approaches to World Politics for the 1990s*, Lexington Books, Lexington, 1989.

Capra, Fritjof, 'Complexity and Life', *Theory, Culture and Society*, vol. 22, no. 5, 2005, pp. 33-44.

Carbone, A., G. Kaniadakisa and A.M. Scarfonea, 'Where do we Stand on Econophysics?', *Physica A: Statistical Mechanics and its Applications*, vol. 382, no. 1, pp. xi-xiv.

Carlsnaes, Walter, 'The Agency-Structure Problem in Foreign Policy Analysis', *International Studies Quarterly*, vol. 36, no. 3, 1992, pp. 245-70.

Carr, E. H., *What is History*, 2nd ed., Penguin, London, 1961.

___________, *The Twenty Years' Crisis 1919-1939: An Introduction to the Study of International Relations*, reissued with a new introduction and additional material by Michael Cox, Palgrave, New York, 2001.

Carr, Paul H., 'Does God Play Dice? Insights From the Fractal Geometry of Nature', *Zygon*, vol. 39, no. 4, 2004, pp. 933-40.

Carroll, James, 'Warring with God', *Boston Globe*, 21st October 2003, p. A19.

Cassier, Ernst, *The Philosophy of the Enlightenment*, trans. Fritz C. A. Koelln and James P. Pettegrove, Princeton University Press, Princeton, 1968.

Casti, John L, 'Complexity - An Introduction', http://www.giacs.org/files/exystence_files/casti.pdf, (accessed 17/08/2004).

Cederman, Lars-Erik, 'Modeling the Size of Wars: From Billiard Balls to Sandpiles', *American Political Science Review*, vol. 97, no. 1, 2003, pp. 135-50.

___________, *Emergent Actors in World Politics; How States and Nations Develop and Dissolve*, Princeton University Press, Princeton, 1997.

Cerny, Philip G., 'Globalization and the Changing Logic of Collective Action', *International* Organisation, vol. 49, no. 4, 1995, pp. 595-625.

Chaos and Fractals, 'Iterated Function Systems', http://www.pha.jhu.edu/~ldb/seminar/ifs.html, (accessed 13/10/2007).

Chatterjee, Sangit and Mustafa R. Yilmaz, 'Chaos, Fractals and Statistics', *Statistical Science*, vol. 7, no. 2, 1992, pp. 49-68.

Checkel, Jeffery T., 'International Norms and Domestic Politics: Bridging the Rationalist—Constructivist Divide', *European Journal of International Relations*, vol. 3, no. 4, 1997, pp. 473-95.

___________, 'The Constructivist Turn in International Relations Theory', *World Politics*, vol. 50, no. 2, 1998, pp. 324-48.

Chernoff, Fred, 'Scientific Realism as a Meta-Theory of International Politics', *International Studies Quarterly*, vol. 46, no. 2, 2002, pp. 189-207.

Chesters, Graeme, 'Global Complexity and Global Civil Society', *Voluntas: International Journal of Voluntary and Nonprofit Organizations*, vol. 15, no. 4, 2004, pp. 323- 42.

Chomsky, Noam, 'Language and Nature', *Mind*, vol. 104, no 413, 1995, pp. 1-61.

Cilliers, Paul, 'Complexity, Deconstruction and Relativism', *Theory, Culture and Society*, vol, 22, no. 5, 2005, pp. 255-67.

___________, *Complexity and Postmodernism*, Routledge, London & New York, 1998.

___________,'What Can We Learn From a Theory of Complexity', *Emergence*, vol. 2, no. 1, 2000, pp. 22-33.

Clark, Andy, 'Where Brain, Body, and World Collide', *Daedalus*, vol. 127, no. 2, 1998, pp. 257-80.

Clark, Ian, 'Beyond the Great Divide: Globalization and the Theory of International Relations', *Review of International Studies*, vol. 24, no. 4, 1998, pp. 479-98.

___________, *Reform and Resistance in the International Order*, Cambridge University Press, Cambridge, 1980.

Clemens Jr., Walter C., *The Baltic Transformed: Complexity Theory and European Security*, Rowman and Littlefield Publishers, Boston, 2001.

___________, 'Understanding and Coping with Ethnic Conflict and Development Issues in Post Soviet Eurasia' in Neil E. Harrison, ed., *Complexity in World Politics: Concepts and Methods of a New Paradigm*, State University of New York Press, Albany, 2006.

Cobden, Richard, *Political Writings*, W. Ridgeway, London, 1878.

Cochran, Molly, *Normative Theory in International Relations*, Cambridge University Press, Cambridge, 1999.

Cochrane, Peter, 'Virtual Mathematics', *The Mathematical Gazette*, vol. 80, no. 488, 1996, pp. 267-78.

Cohen, I. Bernard, 'Newton in the Light of Recent Scholarship', *Isis*, vol. 51, no. 4, 1960, pp. 489-514.

Cohen, H. Floris, *The Scientific Revolution: A Historiographical Inquiry*, University of Chicago Press, Chicago, 1994,

Cohen, Jack and Ian Stewart, *The Collapse of Chaos: Discovering Simplicity in a Complex World*, Penguin, London, 1995.

Colander, David, 'The Death of Neoclassical Economics', *Journal of the History of Economic Thought*, vol. 22, no. 2, 2000, pp. 127-43.

Collier, John, 'Self-organization, Individuation and Identity', *Revue Internationale de Philosophie*, vol. 59, no 5, 2004, pp. 151-72.

Comte, Auguste, *A General View of Positivism*, J.H. Bridges trans., Robert Speller & Sons, London, 1957 [1848].

Conley, Tom, 'The State of Globalisation and the Globalisation of the State', *Australian Journal of International Affairs*, vol. 56, no. 3, 2002, pp. 447 – 71.

Constanza, Robert, 'A Vision of the Future of Science: Reintegrating the Study of Humans and the Rest of Nature', *Futures*, vol. 35, no. 6, 2003, pp. 651-71.

Copleston, Frederick Charles, *A History of Philosophy: Volume III Late Medieval and Renaissance*, Continuum, New York, 2003 [1956].

Corning, Peter A., 'The Re-Emergence of "Emergence": A Venerable Concept in Search of a Theory', *Complexity*, vol. 7, no. 6, 2002, pp. 18-30.

Cottingham, John, 'Descartes' in Ray Monk and Frederic Raphael, eds, *The Great Philosophers*, Phoenix, London, 2004.

Coveney, Peter V., 'Self-Organization and Complexity: a New Age for Theory, Computation and Experiment', *Philosophical transactions of The Royal Society,* vol. 361, no. 1807, 2003, pp. 1057-79.

Cox, Robert W., 'Civil Society at the Turn of the Millennium: Prospects for an Alternative World Order', *Review of International Studies*, vol. 25, no. 1, 1999, pp. 3-28.

___________, *Approaches to World Order,* with Timothy J. Sinclair, Cambridge University Press, Cambridge, 1996.

Coxeter, H. S. M., 'The Non-Euclidean Symmetry of Escher's Picture 'Circle Limit III'', *Leonardo*, vol. 12, no. 1, 1979, pp. 19-25.

Cozette, Murielle, 'Reclaiming the Critical Dimensions of Realism: Hans J. Morgenthau on the Ethics on Scholarship', *Review of International Studies*, vol. 34, no. 1, 2008, pp. 5-27.

Crawford, Robert M. A., 'Where have all the theorists gone?' in Robert M. A. Crawford, and Darryl S. L. Jarvis, eds, *International Relations – Still an American Social Science: Towards Diversity in International Thought*, State University of New York Press, Albany, 2001.

Croce, Benedetto, *The Philosophy of Giambattista Vico*, Trans. R. G. Collingwood, Russell and Russell, New York, 1964.

Cuddy-Keane, Melba, 'Modernism, Geopolitics and Globalization', *Modernism/modernity*, vol. 10, no. 3, 2003, pp. 539-58.

Czempiel, Ernst-Otto 'Internationalizing Politics: Some Answers to the Question of Who Does What to Whom' in Ernst-Otto Czempiel and James Rosenau, eds, *Global Changes and Theoretical Challenges: Approaches to World Politics for the 1990s*, Lexington Books, Lexington, 1989.

da Vinci, Leonardo, *A Deluge* [1517], The Royal Collection: Royal Palaces, Residencies and Art Collections, www.royalcollection.org.uk, (accessed 10/05/2007).

Dahl, Robert A., *Who Governs? Democracy and Power in an American City*, Yale University Press, New Haven and London, 1961.

Darwin, Charles, Descent of Man, and Selection in Relation to Sex, 2nd ed., John Murray, London, 1901 [1878].

___________, *On the Origin of Species by Means of Natural Selection, or the Preservation of Favoured Races in the Struggle for Life*, 1st ed. (reprinted), Watts & Co., London, 1950 [1859].

Davies, Paul, 'Preface', in Philip Clayton and Paul Davis, *The Re-Emergence of Emergence: The Emergent Hypothesis From Science to Religion*, Oxford University Press, Oxford, 2006.

___________, 'The Synthetic Path' in John Brockman, ed., *The Third Culture: Beyond the Scientific Revolution*, Simon & Schuster, 1995, http://www.edge.org/documents/ThirdCulture/za-Ch.18.html, accessed 17/02/2006.

Dawson, John W., 'Gödel and the Limit of Logic', *American Scientific*, June 1999, pp. 68-73.

de Santillana, George, 'Vico and Descartes', *Osiris*, vol. 9, no. 1, 1950, pp. 565-80.

Dear, Peter, *Revolutionizing the Sciences: European Knowledge and its Ambitions, 1500-1700*, Palgrave, Houndsmill, 2001.

DeBenedetti, Charles, 'James T. Shotwell and the Science of International Politics' *Political Science Quarterly*, vol. 89, no. 2, 1974, pp. 379-395.

Deibert, Ronald J. and Janice Gross Stein, 'Hacking Networks of Terror', *Dialogue IO*, vol. 1, no. 1, 2002, pp. 1-14.

Der Derian, James, 'Post-Theory: The Eternal Return of Ethics in International Relations', in Michael W. Doyle, and John G. Ikenberry, *New Thinking in International Relations Theory*, Westview Press, Boulder, 1997.

Descartes, René, *Discourse on Method and Related Writings*, trans., Desmond M. Clarke, Penguin, London, 1998.

___________, *Meditations on First Philosophy: with selections from the Objections and Replies*, trans. and ed. John Cottingham, Cambridge University Press, New York, 1996.

Deutsch, Karl W. and David J. Singer, 'Multipolar Power Systems and International Stability', *World Politics*, vol. 16, no. 3, 1964, pp. 390-406.

Devaney, Robert L., 'Dynamics of Simple Maps' in Robert L. Devaney and Linda Keen, eds, *Chaos and Fractals: The Mathematics Behind the Computer Graphics*, *Proceedings of Symposia in Applied Mathematics*, vol. 39, American Mathematical Society, Providence, 1989.

Dharampala Thangka Centre, School of Thangka Painting, http://www2.bremen.de/info/nepal/Table1.htm, accessed, 12/08/07.

Diamond, Marie Josephine, 'The Social Configuration of Descartes' Discourse on Method', *Dialetical Anthropology*, vol. 7, no. 1, 1982, pp. 1-9.

Dieks, Dennis and Henk W. de Regt, 'Reduction and Understanding', *Foundations of Science*, vol. 1, 1998, pp. 45-59.

diZerega, Gus, 'Emergent Order and Liberal Political Theory', *The Good Society*, vol. 11, no. 3, 2002, pp. 29-33.

Domski, Mary, 'The Construction and the Intelligible in Newton's Philosophy of Geometry', *Philosophy of Science*, vol. 70, no. 5, 2003, pp. 1114-24.

Dooley, Brendan M., *The Social History of Skepticism: Experience and Doubt in Early Modern Culture*, John Hopkins University Press, Baltimore, 1999.

Dooley, Kevin, 'A Nominal Definition of Complex Adaptive Systems', *The Chaos Network*, vol. 8, no. 1, 1996, pp. 2-3.-

Dostoyevsky, Fyodor, *Notes From the Underground*, Michael R. Katz, trans. and ed., W. W. Norton & Company, New York and London ,1989 [1864].

Dow, Sheila C., 'Interpretation: The Case of David Hume', *History of Political Economy*, vol. 34, no. 2, 2002, pp. 399-420.

Dowd, Maureen, 'We're Not Happy Campers', *The New York Times*, September 11, 2003, p. A25.

Dowding, Keith, 'Three Dimensional Power: A Discussion of Steven Lukes' *Power: A Radical View*', *Political Studies Review*, vol. 4, no. 2, 2006, pp. 136-45.

Drinkwater, Derek, *Sir Harold Nicolson and International Relations: The Practitioner as Theorist*, Oxford University Press, Oxford, 2005.

du Plessis, Anton, 'International Relations Theory and the Discourse on Terrorism: Preliminary Reflections on Context and Limits', *Strategic Review for Southern Africa*, vol. 23, no. 2, 2001, pp. 134-152.

Dyrberg, Torben Bech, *The Circular Structure of Power: Politics, Identity, Community*, Verso, London, 1997.

Dyson, Freeman, 'Characterizing Irregularity', *Science*, vol. 200, no. 4342, 1978, pp. 677-8.

Earnest, David C., and James N. Rosenau, 'Signifying Nothing? What Complex System Theory Can and Cannot Tell Us about Global Politics' in Neil E.,Harrison, ed., *Complexity in World Politics: Concepts and Methods of a New Paradigm*, State University of New York Press, Albany, 2006.

Echevarria II, Antulio, 'Tomorrow's Army: The Challenge of Nonlinear Change', *Parameters*, vol. 28 no. 3, 1998. pp. 85-98.

Eidelson, Roy J., 'Complex Adaptive Systems in the Behavioral and Social Sciences', *Review of General Psychology*, vol. 1, no. 1, 1997, pp. 42-71.

Ekelund Jr., Robert B. and Robert F. Hébert, 'The Origins of Neoclassical Microeconomics', *Journal of Economic Perspectives*, vol. 16, no. 3, 2002, pp. 197-215.

Elkana, Yahuda, 'Newtonianism in the Eighteenth Century', *The British Journal for the Philosophy of Science*, vol. 22, no. 3, 1971, pp. 297-306

Elman, Colin and Miriam Fendius Elman, 'How not to be Lakatos Intolerant: Appraising Progress in IR Research', *International Studies Qaurterly*, vol. 46, no. 2, 2002, pp. 231-62.

___________, 'The Role of History in International Relations', *Millennium – Journal of International Studies*, vol. 37, no. 2, 2008, pp. 357-64.

El Naschie, M. S., 'The VAK of Vacuum Fluctuation, Spontaneous Self-Organization and Complexity Theory Interpretation of High Energy Particle Physics and the Mass Spectrum', *Chaos, Solitons & Fractals*, vol. 18, no 2, 2003, pp. 401-420.

Eliot, T. S., *The Complete Poems and Plays*, 1909-1950, Harcourt Brace Jovanovich, New York, 1971.

Elkana, Yehuda, 'The Myth of Simplicity' in Holton, Gerald and Elkana, Yehuda, eds, *Albert Einstein: Historical and Cultural Perspectives*, Princeton University Press, Princeton, 1982.

Emmeche, Claus, Simo Køppe and Frederik Stjernfelt, 'Levels, Emergence, and Three Versions of Downward Causation', in Peter Bøgh Andersen, Claus Emmeche, Niels Ole Finnemann and Peder Voetmann Christiansen, eds, *Downward Causation: Minds, Bodies and Matter*, Århus, Aarhus University Press, 2000.

___________, 'Explaining Emergence: Towards an Ontology of Levels', *Journal for General Philosophy of Science*, vol. 28, no. 1, 1997, pp. 83-119.

Emmet, Dorothy, 'The Concept of Power' in John R. Champlin, ed., *Power*, Atherton Press, New York, 1971, p. 79.

Epstein, Julia L., 'Voltaire's Myth of Newton', *Pacific Coast Philology*, vol. 14, 1979, pp. 27-33.

Escher, M. C., *Circle Limit III* [1959], The Official M.C. Escher Website, 'Picture gallery "Recognition and Success 1955 – 1972"', http://www.mcescher.com/Gallery/gallery-recogn.htm, (accessed 10/05/2007).

Evans, Michael, 'Call for Answers After Intelligence Failure' *The Times*, September 12, 2001.

Evans, Peter, 'The Eclipse of the State? Reflections on Stateness in an Era of Globalisation', *World Politics*, vol. 50, no. 1, 1997, pp. 62-87.

Ewing, John, 'Can we see the Mandelbrot Set?', *The College Mathematics Journal*, vol. 26, no. 2, 1995, p. 90-99.

Falconer, Kenneth, *Fractal Geometry: Mathematical Foundations and Applications*, 2nd ed., Wiley, Chichester, 2003.

Farr, James, 'Political Science and the Enlightenment of Enthusiasm', *American Political Science Review*', vol. 82, no. 1, 1988, pp. 51-69.

Ferguson Yale H., and Richard W. Mansbach, *Remapping Global Politics: History's Revenge and Future Shock*, Cambridge University Press, Cambridge, 2004.

__________, 'Global Politics at the Turn of the Millennium: Changing Bases of "Us" and "Them"', *International Studies Review*, vol. 1, no. 2, 1999, pp. 77-107.

__________, *The Elusive Quest: Theory and International Politics*, University of South Carolina Press, Columbia, 1988.

Findlay, J. N., 'Notes on Plato's Timaeus', *The Philosophical Forum*, vol. 38, no. 2, 2007, pp. 159-71.

Finkelberg, Aryeh, 'Plato's Method in Timaeus', *The American Journal of Philology*, vol. 117, no. 3. 1996 p. 391-409.

Forsyth, Murray, 'Thomas Hobbes: *Leviathan*' in Murray Forsyth, and Maurice Keens-Soper, eds, *The Political Classics: A Guide to the Essential Texts from Plato to Rousseau*', Oxford University Press, Oxford and New York, 1988.

Foster, John, 'From Simplistic to Complex Systems in Economics' *Cambridge Journal of Economics*, vol. 29, no.? 2005, pp. 873-92.

Foucault, Michel, *Discipline and Punish: The Birth of Prison*, trans Alan Sheridan, Penguin, London, 1977.

Franke, Herbert W., 'Refractions of Science into Art', H.-O. Peitgen and P.H. Richter, *The Beauty of Fractals: Images of Complex Dynamical Systems*, Springer-Verlag, Berlin, 1986.

Freedman, Amy L., 'Economic Crises and Political Change: Indonesia, South Korea, and Malaysia', *Asian Affairs: An American* Review, vol. 31, no. 4, 2005, pp. 232-249.

Freud, Sigmund, *Civilization and its Discontents*, trans. and ed. James Strachey, W.W. Norton and Company, New York, 1962.

__________, *The Interpretation of Dreams*, 3rd (rev. English) ed., James Strachey, trans and ed., George Allen and Unwin, London, 1954 [1931].

Friedman, Thomas, 'The War on What?', *The New York Times*, May 8, 2002, p. A31.

__________, *The Lexus and the Olive Tree*, HarperCollins, London, 1999.

Frigg, Roman, 'Self-Organised Critically – What it is and What it isn't', *Studies in History and the Philosophy of Science*, vol. 34, no. 3, 2003, pp. 613-32.

Fuchs, Christian, 'Social Information and Self-Organisation' in Trappl, Robert ,ed., *Cybernetics and Systems 2002*, vol. 1,Vienna, 2002.

Fuenmayor, Ramsés, 'The Roots of Reductionism: A Counter-Ontoepistemology for a Systems Approach', *Systems Practice*, vol. 4, no. 5, 1991, pp. 419-47.

Fukuyama, Francis, 'Beyond Our Shores', *The Wall Street Journal*, December 24, 2002, p. A10.

__________, 'Reflections on the End of History, Five Years Later', *History and Theory*, vol. 34, no. 2, 1995, pp. 27-43.

__________, 'The End of History', *The National Interest*, vol. 16, 1989, pp. 3-18.

Fuller, Ted and Paul Moran, 'Moving Beyond Metaphor', *Emergence*, vol. 2, no. 1, 2000, pp. 50-71.

Gaddis, John Lewis, 'In Defence of Particular Generalizations: Rewriting Cold War History, Rethinking International Relations Theory' in Colin Elman and Miriam Fendius Elman, eds, *Bridges and Boundaries: Historians, Political Scientists and the Study of International Relations*, Massachusetts Institute of Technology Press, Cambridge, 2001.

__________, 'International Relations Theory and the End of the Cold War ', *International Security*, vol. 17, no. 3, 1992, pp. 5-58.

Galbraith, John Kenneth, *The World Economy Since the Wars: A Personal View*, Sinclair-Stevenson, London, 1994.

Gangly, William T. 'Institutional Economics and Neoclassicism in the Early Twentieth Century: The role of Physics', *Journal of Economic Issues*, vol. 24, no. 2, 1995, pp. 397-406.

Garran, Robert, *Tigers Tamed: The End of the Asian Miracle*, Allen & Unwin, St. Leonards, 1998.

Garreau, Joel, 'Disconnect the Dots', *Washington Post*, Monday, September 17, 2001, p.C01.

Gaukroger, Stephen, 'Descartes: Methodology', in George Henry Radcliffe Parkinson, ed., The Routledge History of Philosophy, Vol 4: *The Renaissance and Seventeenth-Century Rationalism*, Routledge, London, 1993.

Geertz, Clifford, *The Interpretation of Cultures*, Basic Books, New York, 1973.

Gell-Mann, Murray, *The Quark and the Jaguar: Adventures in the Simple and the Complex*, Abacus, London, 1994.

__________, The Simple and the Complex', in David S. Alberts, and Thomas J. Czerwinski, (eds.), *Complexity, Global Politics, and National Security*, National Defence University, Washington D.C., 1997.

Gergen, Kenneth J., 'Metaphor, Metatheory, and the Social World' in David E. Leary, ed., *Metaphors in the History of Psychology*, Cambridge University Press, Cambridge, 1994.

Gerring, John, 'What Makes a Concept Good? A Critical Framework for Understanding Concept Formation in the Social Sciences', *Polity*, vol. 31, no. 3, 1999, pp. 357-93.

Geyer, Robert, 'Beyond the Third Way: The Science of Complexity and the Politics of Choice', *British Journal of Politics and International Relations*, vol. 5, no. 2, 2003, pp. 237-57.

___________, 'Globalization, Europeanization, Complexity, and the Future of Scandinavian Exceptionalism', *Governance: An International Journal of Policy, Administration, and Institutions*, vol. 16, no. 4, 2003, pp. 559-76.

Giddens, Anthony, 'Jürgen Habermas', in Quentin Skinner, ed., *The Return of Grand Theory in the Human Sciences*, Cambridge University Press, Cambridge, 1985.

___________, *Beyond Left and Right: the Future of Radical Politics*, Stanford University Press, Stanford, 1994.

___________, *Consequences of Modernity*, Polity Press, Cambridge, 1990.

___________, *Sociology: A Brief but Critical Introduction*, MacMillan Press, London 1982.

Gilkey, Langdon B., 'Introduction' in Reinhold Niebuhr, *Moral Man and Immoral Society: A Study in Ethics and Politics*, Westminster John Knox Press, Louisville, 2002 [1960].

Gleick, James, *Chaos: Making a New Science*, Sphere Books, London, 1988.

Goddard, Stacie E. and Daniel H. Nexon, 'Paradigm Lost? Reassessing Theory of International Politics', *European Journal of International Relations*, vol. 11, no. 1, 2005, pp. 9-61.

Goethe, Johann Wolfgang von, *Elective Affinities : a Novel*, Trans. James Anthony Froude and R. Dillon Boylan, Ungar Publishing, New York, 1962 [1809].

Goh, Evelyn, 'Hegemonic Constraints: the Implications of 11 September for American Power', *Australian Journal Of International Affairs*, vol. 57, no. 1, 2003, pp. 77-97

Goldspink, Chris, 'Contrasting Linear and Nonlinear Perspectives in Contemporary Social Research', *Emergence*, vol. 2, no. 2, 2000, pp. 72–101.

Goldstein, Jeffrey, 'Emergence as a Construct: History and Issue', *Emergence*, vol. 1, no. 1, pp. 49-72.

Goldstone, Jack A., 'Efflorescences and Economic Growth in World History: Rethinking the "Rise of the West" and the Industrial Revolution', *Journal of World History*, Fall 2002 vol. 13, no. 2 pp. 323-89.

Gould, Stephen Jay, 'The Patterns of Life's History' in John Brockman, ed., *The Third Culture: Beyond the Scientific Revolution*, Simon & Schuster, 1995, http://www.edge.org/documents/ThirdCulture/i-Ch.2.html, (accessed 19/04/2004).

Goya y Lucientes, Francisco José de, *The Sleep of Reason Produces Monsters (El Sueño de la Razon Produce Monstruos)*, Plate 43 of *Los Caprichos*, second edition, ca. 1803, Herbert F. Johnson Museum of Art, Cornell University, http://www.museum.cornell.edu/HFJ/handbook/hb128.html, (accessed 25/03/2006).

Grant, Ruth W., 'The Ethics of Incentives: Historical Origins and Contemporary Understandings', *Economics and Philosophy*, vol. 18, no. 1, 2002, pp. 111-139.

Grass, Günter, 'The Moral Decline of a Superpower', *International Herald Tribune*, April 10, 2003, http://www.iht.com/articles/92716.htm, (accessed 19/04/2003).

Gray, Robert, *Goethe: A Critical Introduction*, Cambridge University Press, Cambridge, 1967.

Gribbin, John, *Deep Simplicity: Chaos, Complexity and the Emergence of Life*, Penguin Books, London, 2004.

Griffiths, Martin, *Fifty Key Thinkers in International Relations*, Routledge, New York, 1999.

__________, 'Self-Inflicted Wounds: United States Grand Strategy and the War on Terror', refereed paper presented to the Australasian Political Studies Conference, University of Tasmania, Hobart, 29 September – 1 October, 2003.

__________, ed., *The Encyclopedia of International Relations and Global Politics*, Routledge, New York, 2005.

Grosholz, Emily, 'Geometry, Time and Force in the Diagrams of Descartes, Galileo, Torricelli and Newton', *PSA: Proceedings of the Biennial Meeting of the Philosophy of Science Association*, vol. 2: Symposia and Invited Papers, 1988, pp. 237-48.

__________, *Cartesian Method and the Problem of Reduction*, Clarendon Press, Oxford, 1991.

Gunaratne, Shelton A., 'Thank you Newton, Welcome Prigogine: 'Unthinking' Old Paradigms and Embracing New Directions. Part 1: Theoretical Distinctions', *Communications*, vol. 28, no. 4, 2003, pp. 435-55.

_________, 'Thank you Newton, Welcome Prigogine: 'Unthinking' Old Paradigms and Embracing New Directions. Part 2: The Pragmatics', *Communications*, vol. 29, no. 2, 2004, pp. 113-32.

Gündüz, Güngör, 'The Fractal Dimension of the Rise of an Empire', *The Journal of Mathematical Sociology*, vol. 24, no. 4, 2000, pp. 303-320.

Gunnell, John G., 'Paradoxos Theoretikos' in Kristen R. Monroe, ed., *Contemporary Empirical Political Theory*, University of California Press, Berkley, 1997.

_________, 'Realizing Theory: The Philosophy of Science Revisited', *The Journal of Politics*, vol. 57, no. 4, 1995, pp. 923-40.

Guyon, Etienne and H. Eugene Stanley, eds, *Fractal Forms*, Elsevier Science Publishers and Palais de la Décorvete, 1991.

Guzzini, Stefano, 'A Reconstruction of Constructivism in International Relations', *European Journal of International Relations*, vol. 6, no. 2, 2000, pp. 147-182.

___________, 'Foreign Policy Without Diplomacy: The Bush Administration at a Crossroads', *International Relations*, vol. 16, no. 2, pp. 291-297.

___________, *Realism in International Relations and the International Political Economy: The Continuing Story of a Death Foretold*, Routledge, London, 1998

___________, 'Structural Power: The Limits of Neorealist Power Analysis', International Organisation, vol. 47, no. 3, 1993, pp. 443-78.

Habermas, Jürgen, *The Theory of Communicative Action: Reason and the Rationalization of Society*, vol. 1, trans. McCarthy, Thomas, Beacon Press, Boston, 1984.

Hall, Rupert, A., *From Galileo to Newton, 1630-1720: The Rise of Modern Science 2*, Fontana Collins, 1963.

Halliday, Fred and Rosenberg, Justin, 'Interview with Ken Waltz', *Review of International Studies*, vol. 24, no. 3, 1998, pp. 371-86.

Hampshire, Stuart, *The Age of Reason: The 17th Century Philosophers*, Mentor Books, London, 1956.

Hardin, Russell, 'The Normative Core of Rational Choice Theory' in Uskali Mäki, ed., *The Economic World View: Studies in the Ontology of Economics*, Cambridge University Press, Cambridge, 2001.

Harmes, Adam, 'The Trouble with Hedge Funds', *Review of Policy Research*, Vol. 19, No. 1, pp. 156-76.

Harrison, Ewan, 'Waltz, Kant and Systemic Approaches to International Relations', *Review of International Studies*, vol. 28, no. 1, 2002, pp. 143-62.

Harrison, Mark, Coercion, Compliance, and the Collapse of the Soviet Command Economy', *Economic History Review*, vol. 55, no. 2, 2002, pp. 397-433.

Harrison, Neil E. 'Complex Systems and the Practice of World Politics' in Harrison, Neil E., ed., *Complexity in World Politics: Concepts and Methods of a New Paradigm*, State University of New York Press, Albany, 2006.

___________, 'Thinking About the World We Make' in Neil E. Harrison, ed., *Complexity in World Politics: Concepts and Methods of a New Paradigm*, State University of New York Press, Albany, 2006.

Harrison, Peter, 'Was there a Scientific Revolution?', *European Review*, vol. 15, no. 4, 2007, pp. 445-57.

Harvey David L., and Michael H. Reed, 'Social Science as the Study of Complex Systems' in Kiel, L. Douglas and Euel Elliot, eds, *Chaos Theory in the Social Sciences: Foundations and Applications*, University of Michigan Press, Ann Arbor, 1996.

___________, 'The Evolution of Dissipative Social Systems', *Journal of Social and Evolutionary Systems*, vol. 17, no. 4, 1994, pp. 347-411.

Harvey, David L., 'Agency and Community: A Critical Realist Paradigm', *Journal for the Theory of Social Behaviour*, vol. 32, no. 2, 2002, p. 163-94.

Haas, Ernst B., 'The Balance of Power: Prescription, Concept, or Propaganda', *World Politics*, vol. 15, no. 4, 1953, pp. 442-77.

Hatch, Mary Jo and Haridimo Tsoukas, 'Complex Thinking About Organizational Complexity: The Appeal of a Narrative Approach to Complexity Theory', Warwick Business School Research Bureau, Research Paper no. 251, 1997.

Hayek, Frederich von, 'The Use of Knowledge in Society', *American Economic Review*, vol. 35, no. 4, 1945, pp. 519-30.

Hayles, N. Katherine, *Chaos Bound: Orderly Disorder in Contemporary Literature and Science*, Cornell University Press, Ithaca and London, 1990.

Hayward, Clarissa Rile, 'De-facing Power', *Polity*, vol. 31, no. 3, 1998, 1-22.

Heelan, Patrick A. and Jay Schulkin, 'Hermeneutical Philosophy and Pragmatism: A Philosophy of Science', *Synthese*, vol. 115, no 3, 1998, pp. 269–302.

Held, David and Anthony McGrew, *Globalization/Anti-Globalization: Beyond the Great Divide*, 2nd ed., Polity Press, Cambridge, 2007.

Helmreich, Stefan, Recombination, Rationality, Reductionism and Romantic Reactions: Culture, Computers, and the Genetic Algorithm', *Social Studies of Science*, vol. 28, no. 1, 1998, pp. 39- 71.

Herman, Arthur, *The Scottish Enlightenment: The Scots' Invention of the Modern World*, Fourth Estate, London, 2001.

Herrmann, Heinz, *From Biology to Sociopolitics: Conceptual Continuity in Complex Systems*, Yale University Press, New Haven, 1998.

Hiebert, Erwin N., 'Book Review: Prigogine Writes on Time Irreversible and Reversible: *From Being to Becoming: Time and Complexity in the Physical Sciences* by Ilya Prigogine', Physics Today, vol. 79, no. 1, 1982, pp. 69-70.

Higgs, Darby, 'APEC as a complex adaptive system: insights on the problem of multilateralism versus bilateralism from a new science', Australian APEC Study Centre, http://www.apec.org.au/docs/higgs.pdf, (accessed 12/03/2005).

Hilborn, Robert C. 'Sea Gulls, Butterflies, and Grasshoppers: A Brief History of the Butterfly Effect in Nonlinear Dynamics', *American Journal of Physics*, vol. 72, no. 4, pp. 425-7.

Hill, Lisa, 'The Invisible Hand of Adam Ferguson', *The European Legacy*, (formerly *History of European Ideas*), vol. 3, no. 6, 1998, pp. 42-65.

___________, *The Passionate Society: The Social, Political and Moral Thought of Adam Ferguson*, Springer, Dordrecht, 2006.

Hoagland, Jim, 'Seeing Asia Whole', *Washington Post*, February 21, 2002, p.A21.

Hobbes, Thomas, *Leviathan*, C. B. Macpherson, ed., Penguin Books, Harmondsworth, 1968 [1651].

Hobden, Stephen and John M. Hobson, eds, *Historical Sociology of International Relations*, Cambridge University Press, 2002.

Hobsbawm, Eric, *The New Century: In Conversation with Antonio Polito*, Trans. Allen Cameron, Abacus, London, 2000.

Hobson, J. A., *Richard Cobden: The International Man*, T. Fisher Unwin Ltd, London, 1918.

Hobson, John M., 'The 'Second State Debate' in International Relations: Theory Turned Upside-Down', *Review of International Studies*, vol. 27, no. 3, 2001, pp. 395-414.

Hodgson, Geoffrey M., 'Economics and the Return to Mecca: the Recognition of Novelty and Emergence', *Structural Change and Economic Dynamics*, vol. 8, no. 4, 1997, pp. 399-412.

Hoffmann, Matt and David Johnson, 'Change and Process in a Complex World: Using Complexity Theory to Understand World Politics, Paper presented at the Annual Meetings of the International Studies Association, Minneapolis, Minnesota, March 18-21, 1998.

Hoffmann, Stanley, 'An American Social Science: International Relations', *Daedelus*, vol.106, no. 3, 1977, pp. 41-60.

___________, 'America Goes Backward', *The New York Review of Books*, vol. 50, no. 10, June 12, 2003, pp. 74-80.

___________, 'Clash of Globalizations', *Foreign Affairs*, vol. 81, no. 4, 2002 pp. 104-115.

___________, 'The High and the Mighty; Bush's National-Security Strategy and the New American Hubris', *The American Prospect*, January 13, 2003, pp. 28-31.

___________, *The State of War: Essays on the Theory and Practice of International Politics*, Pall Mall Press, London, 1965.

Hokusai, Katsushika, *The Great Wave at Kanagawa* [ca. 1830–32], The Metropolitan Museum of Art, New York, http://www.metmuseum.org/, (accessed 23/09/2007).

Holland, John, *Emergence: From Chaos to Order*, Oxford University Press, Oxford and New York, 1998.

___________, *Hidden Order: How Adaptation Builds Complexity*, Addison-Wesley, New York, 1995.

Holm, Soren, 'Does Chaos Theory have major implications for Philosophy of Medicine', *Journal of Medical Ethics: Medical Humanities*, vol. 28, 2002, pp. 78-81.

Holsti, Kal J., 'The Institutions of International Politics: Continuity, Change, and Transformation', Paper presented at the Annual Meetings of the International Studies Association, New Orleans, Louisiana, March 23-27, 2002.

Holy Bible, vol. 1, King James ed., Oxford University Press, Oxford, 1895 [1611].

Homer-Dixon, Thomas, 'The Rise of Complex Terrorism', Foreign Policy, no. 128, 2002, pp. 52–62.

___________, 'On the Threshold: Environmental Changes as Causes of Acute Conflict', *International Security*, vol. 16, no. 2, 1991, pp. 76-116.

Hopf, Ted, *Social Construction of International Politics: Identities & Foreign Policies, Moscow, 1955 and 1999*, Cornell University Press, Ithaca, 2002.

Hotz, Robert, 'A Study in Complexity', *MIT's Technology Review*, vol. 100, no. 7, pp. 22-9.

Hull, D. L. and van M. Regenmortel, eds, *Promises and Limits of Reductionism in the Biomedical Sciences*, John Wiley and Sons, New York, 2002.

Hull, David L., 'What's Wrong with Invisible-Hand Explanations?', *Philosophy of Science: Supplement. Proceedings of the 1996 Biennial Meetings of the Philosophy of Science Association*, vol. 64, 1997, pp. S117-26.

Hume, David, 'On the Balance of Power', *Essays, Moral, Political, and Literary*, Eugene F. Miller, ed., Liberty Classic, Indianapolis, 1985 [1777].

___________, 'That Politics May be Reduced to a Science', *Selected Essays*, Oxford University Press, Oxford, 1996 [1741].

___________, *A Treatise of Human Nature: Book II: Of the Passions*, edited, with analytical index, by L.A. Selby-Biggs, Clarendon Press, London, 1888 [1739].

___________, *The Natural History of Religion*, edited with introduction by H.E. Root, Adam & Charles Black, London, 1956 [1777].

Huntington, Samuel, *The Clash of Civilizations and the Remaking of World Order*, Touchstone Books, New York, 1996.

Hurrell, Andrew, *On Global Order: Power, Values, and the Constitution of International Society*, Oxford University Press, Oxford, 2007.

Ignatius, David, 'Netting Bin Laden', *Washington Post*, November 11, 2001, p. B07.

Ikenberry, John G. and Michael W. Doyle, 'Conclusion: Continuity and Innovation in International Relations Theory' in Michael W. Doyle, and John G. Ikenberry, *New Thinking in International Relations Theory*, Westview Press, Boulder, 1997.

Ikenberry, G. John, 'Institutions, Strategic Restraint, and the Persistence of American Postwar Order', *International Security*, vol. 23, no. 3, Winter 1998, pp. 43-78.

___________, ed., *America Unrivaled: The Future of the Balance of Power*, Cornell University Press, Ithaca and London, 2002.

Ilie, Paul, 'Goya's Teratology and the Critique of Reason', *Eighteenth-Century Studies*, vol. 18, no. 1, 1984, p. 38.

Ish-Shalom, Piki, 'Theory as a Hermeneutical Mechanism: The Democratic-Peace Thesis and the Politics of Democratization', *European Journal of International Relations*, vol. 12, no. 4, 2006 pp. 565-98.

Jackson, William A., 'Naturalism in Economics', *Journal of Economic Issues*, vol. 29, no. 3, 1995, pp. 761-80.

Jeans, James, *Physics and Philosophy*, Cambridge University Press, Cambridge, 1943.

Jepperson, Ronald L., Alexander Wendt, and Peter J. Katzenstein, 'Norms, Identity, and Culture in National Security', in Katzenstein, Peter J., ed., *The Culture of National Security: Norms and Identity in World Politics*, Columbia University Press, New York, 1996.

Jervis, Robert, 'A Political Science Perspective on the Balance of Power and the Concert', *The American Historical Review*, vol. 97, no. 3, 1992, pp. 716-724

___________, 'An Interim Assessment of September 11: What Has Changed and What Has Not?', *Political Science Quarterly*, vol. 117, no. 1, Spring 2002, pp. 37-54.

___________, 'Complex Systems: The Role of Interactions', in David S. Albert and Thomas J. Czerwinski, eds, *Complexity, Global Politics and World Affairs*, University Press of the Pacific, Honolulu, 1997

___________, 'Realism, Neoliberalism, and Cooperation', *International Security*, vol. 24, no. 1, 1999, pp. 42-63.

___________, *Perception and Misperception in International Politics*, Princeton University Press, Princeton, 1976.

___________, *System Effects: Complexity in Political and Social Life*, Princeton University Press, Princeton, 1997.

Johnson, Bob, 'An Example of Chaotic Dynamics', *Mathematical Gazette*, vol. 74, no. 469, 1990, pp. 256-60.

Johnson, Steven, *Emergence: The Connected Lives of Ants, Brains, Cities and Software*, Allen Lane: The Penguin Press, London, 2001.

Jones, Roy E., *Analysing Foreign Policy: An Introduction to Some Conceptual Problems*, Routledge and Keegan Paul, London, 1970.

Jost, John T., Christopher M. Federico and Jaime L. Napier, 'Political Ideology: Its Structure, Functions, and Elective Affinities', *Annual Review of Psychology*, vol. 60, 2009, pp. 307-37.

Kahler, Miles, 'Inventing International Relations: International Relations Theory After 1945', in Michael W. Doyle and John G. Ikenberry, *New Thinking in International Relations Theory*, Westview Press, Boulder, 1997.

Kaplan, Morton A., 'The New Great Debate: Traditionalism vs. Science in International Relations', *World Politics*, vol. 19, no. 1,1966, pp. 1-20.

Kaplan, Robert, 'The Coming Anarchy', *The Atlantic Monthly*, vol. 273, no. 2, February 1994, pp. 44-76.

Kauffman, Stuart A., *At Home in the Universe: The Search for Laws of Self-Organization and Complexity*, Oxford University Press, Oxford and New York, 1995.

___________, *Investigations*, Oxford University Press, New York, 2000.

___________, 'Order for Free' in John Brockman, ed., *The Third Culture: Beyond the Scientific Revolution*, Simon & Schuster, 1995, http://www.edge.org/documents/ThirdCulture/zd-Ch.20.html, (accessed 19/4/2004).

___________, *The Origins of Order: Self-Organization and Selection in Evolution*, Oxford University Press, New York, 1993.

Kavalski, Emilian, 'The Complexity of Global Security Governance: An Analytical Overview', Global Society, vol. 22, no. 4, 2008, pp. 423-43.

___________, 'The Fifth Debate and the Emergence of Complex International Relations Theory: Notes on the Application of Complexity Theory to the Study of International Life', *Cambridge Review of International Affairs*, vol. 20, no. 3, 2007, pp. 435-54.

Keen, Linda, 'Julia Sets' in Robert L. Devaney and Linda Keen, eds, *Chaos and Fractals: The Mathematics Behind the Computer Graphics, Proceedings of Symposia in Applied Mathematics*, vol. 39, American Mathematical Society, Providence, 1989.

Keenan, George F., *Memoirs 1925-1950*, Little, Brown and Company, Boston, 1967.

Kellert, Stephen H., 'Extrascientific Uses of Physics: The Case of Nonlinear Dynamics and Legal Theory, *Philosophy of Science*, vol. 68 no. 3, Supplement: Proceedings of the 2000 Biennial Meeting of the Philosophy of Science Association. Part 1: Contributed Papers, 2001, pp. S457-8.

Kennedy, Paul, *The Rise and Fall of the Great Powers: Economic Change and Military Conflict From 1500 to 2000*, Fontana Press, London, 1989.

Kennedy-Pipe, Caroline, 'International History and International Relations Theory: A Dialogue Beyond the Cold War', *International Affairs*, vol. 76, no. 4, 2000, pp. 741-54.

Keohane, Robert O. and Joseph S. Nye Jr., 'Globalization: What's New? What's Not? (And So What?)', *Foreign Policy*, vol. 118, 2000, pp. 104-119.

___________, *Power and Interdependence*, 3rd ed., Longman, New York, 2001.

Keohane, Robert O., ed., *Neorealism and its Critics*, Columbia University Press, New York, 1986.

Kerr, Richard A., 'Does Chaos Permeate the Solar System?', *Science*, vol. 244, no. 4901, 1989, pp. 144-5.

Kessler, Glenn, 'Diplomatic Gap Between U.S., Its Allies Widens', *Washington Post*, September 1, 2002, p. A20.

Kiel, L. Douglas and Euel Elliot, eds, *Chaos Theory in the Social Sciences: Foundations and Applications*, University of Michigan Press, Ann Arbor, 1996.

Kiel, L. Douglas, 'The Nonlinear Parading: Advancing Paradigmatic Progress in the Policy Sciences', *Systems Research*, vol. 9, no. 2, 1992, pp. 27-42.

Kilpatrick Jr., Henry E., 'Complexity, Spontaneous Order, and Friedrich Hayek: Are Spontaneous Order and Complexity Essentially the Same Thing?', *Complexity*, vol. 6, no. 4, 2001, pp. 16-20.

Kim, Jaegwon, 'Being Realistic About Emergence', in Philip Clayton and Paul Davis, *The Re-Emergence of Emergence: The Emergent Hypothesis From Science to Religion*, Oxford University Press, Oxford, 2006.

King, M.D., 'Reason, Tradition and the Progressiveness of Science' in Gary Gutting, ed., *Paradigms and Revolutions: Appraisals and Applications of Thomas Kuhn's Philosophy of Science*, University of Notre Dame Press, Notre Dame, 1980.

Kingsbury, Damien, *The Politics of Indonesia*, Oxford University Press, Melbourne, 1998.

Knutsen, Torbjørn L., A *History of International Relations Theory*, 2nd ed., Manchester University Press, Manchester and New York, 1997.

Koehn, Peter H. and James N. Rosenau, 'Transnational Competence in an Emergent Epoch', *International Studies Perspectives*, vol. 3, no. 2, 2002, pp. 105-27.

Koyré, Alexandre, *Newtonian Studies*, The University of Chicago Press, Chicago, 1965.

Krasner, Stephen D., 'Abiding Sovereignty', *International Political Science Review / Revue internationale de science politique*, vol. 22, no. 3, Transformation of International Relations: Between Change and Continuity / Transformations des relations internationales: entre rupture et continuité, 2001, pp. 229-51.

___________, *Defending the National Interest: Raw Materials Investments and US Foreign Policy*, Princeton University Press, Princeton, 1978.

___________, 'Rethinking the Sovereign State Model', *Review of International Studies*, vol. 27, no. 1, 2001, pp. 17-42.

Kratochwil, Frederick, 'Of False Promises and Good Bets: A Plea for a Pragmatic Approach to Theory Building (the Tartu Lecture), *Journal of International Relations and Development*, vol, 10, no. 1, 2007, pp. 1-15.

___________, 'Politics, Norms and Peaceful Change', *Review of International Studies*, vol. 24, no. 5, 1998, pp. 193-218.

___________, 'Re-Thinking the "Inter" in International Politics', *Millennium: Journal of International Studies*, vol. 35, no. 3, 2007, pp. 495-511.

Kristol, William and Robert Kagan, 'Reject the Global Buddy System', *New York Times*, October 25, 1999, p A31.

Kuhn, Thomas S., '[The New Reality in Art and Science]: Comment', *Comparative Studies in Society and History*, vol. 11, no. 4, 1969, pp. 403-12.

___________, 'The Function of Measurement in Modern Science', *Isis*, vol. 52, no. 2, 1961, pp. 161-93.

___________, *The Structure of Scientific Revolutions*, (International Encyclopaedia of Unified Science, vol. 2, no. 2) University of Chicago Press, Chicago, 1962.

___________, *Structure of Scientific Revolutions*, 2nd ed., (International Encyclopaedia of Unified Science, vol. 2, no. 2) University of Chicago Press, Chicago, 1970.

Kurki, Milja, *Causation in International Relations: Reclaiming Causal Analysis*, Cambridge University Press, Cambridge, 2008.

LaFeber, Walter, 'The Post September 11 Debate Over Empire, Globalization and Fragmentation', *Political Science Quarterly*, vol. 117, no. 1, pp. 1-17.

Lagueux, Maurice, 'The Forgotten Role of the Rationality Principle in Economics', *Journal of Economic Methodology*, vol. 11, no. 1, 2004, pp. 31-51.

Lal, Deepak, 'Globalisation, Imperialism and Regulation', *Cambridge Review of International Affairs*, vol. 14, no. 1, 2000, pp. 107-21.

Lancaster, Alex, 'Life at the Edge of Chaos', http://www.santafe.edu/~alex/life.html, (accessed 21/3/2001).

Lang Jr., Anthony F., 'Introduction' in Hans Morgenthau, *Political Theory and International Affairs: Hans J Morgenthau on Aristotle's the Politics*, ed. Anthony F. Lang Jr., Praeger, Westport, 2004 .

Langton, Christopher G., 'Self-reproduction in cellular automata', *Physica D: Nonlinear Phenomena*, vol. 10, no. 1-2, 1984, pp. 135-44.

Lansing, J. Stephen, 'Complex Adaptive System', *Annual Review of Anthropology*, vol. 32, no. 1, 2003, pp. 183-204.

Laplace, P.S., *A Philosophical Essay on Probabilities*, 6th ed., Trans. by F. W. Truscott and F. L. Emory, Dover Publications, New York, 1951 [1825].

Lauridsen, Laurids S., 'The Financial Crisis in Thailand: Causes, Conduct and Consequences?', *World Development*, vol. 26, no. 8, 1998, pp. 1575-91.

Lawson, George, 'The Promise of Historical Sociology in International Relations', *International Studies Review*, vol. 8, no. 3, 2006, pp. 397–423.

Lebow, Richard Ned, 'The Long Peace, the End of the Cold War, and the Failure of Realism', *International Organisation*, vol. 48, no. 52, 1994, pp. 249-77.

Legro, Jeffrey and Andrew Moavcsik, 'Is Anybody Still a Realist?', *International Security*, vol. 24, no. 2, pp. 5-55.

Levin, Simon A., 'Complex Adaptive Systems: Exploring the Known, the Unknown and the Unknowable', *Bulletin of the American Mathematical Society*, vol. 40, no. 1, 2003, pp. 3-19.

__________, 'Self-Organization and the Emergence of Complexity in Ecological Systems', *BioScience*, vol. 55, no. 12, 2005, pp. 1075-9.

Levy, David L., and Daniel Egan, 'A Neo-Gramscian Approach to Corporate Political Strategy: Conflict and Accommodation in the Climate Change Negotiations', *Journal of Management Studies*, vol. 40, no. 4, 2003, pp. 803-29.

Lewin, Roger, Teresa Parker and Birute Regine, 'Complexity Theory and the Organization: Beyond the Metaphor', *Complexity*, vol. 3, no. 4, 1998, pp. 36-40.

Li, Tien-Yien and James A. Yorke, 'Period Three Implies Chaos', *The American Mathematical Monthly*, vol. 82, no. 10, 1975, pp. 985-92.

Lindstrøm, Tom, 'Brownian Motion on Nested Fractals', *Memoirs of the American Mathematical Society*, vol. 83, no. 420, 1990, pp. 1-128.

Liotta, P. H. and Anna Simons, 'Thicker than Water? Kin, Religion, and Conflict in the Balkans', *Parameters*, vol. 28, no. 4, 1998-99, pp. 11-27.

Liska, George, *Quest for Equilibrium: America and the Balance of Power on Sea and Land*, John Hopkins University Press, Baltimore and London, 1977.

Little, Richard, 'The Balance of Power in *Politics Among Nations*' in Michael C. Williams, ed., *Realism Reconsidered: The Legacy of Hans J. Morgenthau in International Relations*, Oxford University Press, New York, 2007.

__________, *The Balance of Power in International Relations*, Cambridge University Press, Cambridge, 2007.

Litwak, Robert S., 'The Imperial Republic After 9/11", *The Wilson Quarterly*, vol. 26, no. 3, pp. 70-75.

Locher, Birgit and Elisabeth Prügl, 'Feminism and Constructivism: Worlds Apart or Sharing the Middle Ground?', *International Studies Quarterly*, vol. 45, no. 1, 2001, pp. 111-129.

Lomas, Peter, 'Anthropomorphism, Personification and Ethics: a Reply to Alexander Wendt', *Review of International Studies*, vol. 31, no 2. , 2005, pp. 349-55.

Lorenz, Edward N., 'Deterministic Nonperiodic Flow' *Journal of the Atmospheric Sciences*, vol. 20, no. 1, 1963, pp. 130-41.

Lowe, Sid, Fiona Moore, and Adrian N. Carr, 'Paradigmapping Studies of Culture and Organization', *International Journal of Cross Cultural Management*, vol. 7, no. 2, 2007, pp. 237-51.

Lucas, Chris, 'Self-Organising Systems FAQ', April 2001, http://www.calresco.org/sos/sosfaq.htm#1.2, (accessed 16/10/2003).

Lugg, Andrew, ''The Priority of Paradigms' Revisited', *Journal for General Philosophy of Science*, vol. 18, no. 1-2, 1987, pp. 175-82.

__________, 'Review Essay: Kuhn and the Philosophy of Science', *The British Journal for the History of Science*, vol. 12, no. 3, 1979, pp. 289-95.

Lukes, Steven, 'Introduction' in Steven Lukes, ed., *Power*, Basil Blackwell, Oxford, 1986.

__________, *Power: A Radical View*, Macmillan, London, 1974.

__________, 'Power and the Battle for Hearts and Minds: On the Bluntness of Soft Power' in Felix Berenskoelter and Michael J. Williams, eds, *Power in World Politics*, Routledge, Abingdon, 2007.

Luhmann, Niklas, *Social Systems*, trans. John Bednartz Jr., Stanford University Press, Stanford, [1984], 1995.

MacIntyre, Alisdair, *After Virtue: A Study of Moral Theory*, 2nd ed., Duckworth, London, 1985.

Mackenzie, Dana, 'The Science of Surprise: Can complexity theory help us understand the real consequences of a convoluted event like September 11', *Discover*, vol. 23, No. 2, February 2002, pp. 58-62.

Mainzer, Klaus, *Thinking in Complexity: The Complex Dynamics of Matter, Mind, and Mankind*, Spring-Verlag, Berlin, 1994.

Mäki, Uskali, 'Economic Ontology: Why? What? How?', in Mäki, Uskali, ed., *The Economic World View: Studies in the Ontology of Economics*, Cambridge University Press, Cambridge, 2001.

Malhotra, Renu, Matthew Holman and Takashi Ho, 'Chaos and the Stability of the Solar System', *Proceedings of the National Academy of Sciences*, vol. 98, no. 22, 2001, pp. 12342-43.

Mandelbrot, Benoit B., 'Fractal Geometry: What is it, and What does it do?', *Proceedings of the Royal Society of London. Series A, Mathematical and Physical Sciences*, vol. 423, no. 1864, 1989, pp. 21-87.

___________, 'Fractals and an Art for the Sake of Science', *Leonardo: Computer Art in Context Supplemental Issue*, no. 2, 1989, pp. 21-4.

___________, 'Fractals and the Rebirth of Iteration Theory', in Heinz-Otto Peitgen and Peter H. Richter, *The Beauty of Fractals: Images of Complex Dynamical Systems*, Springer-Verlag, Berlin, 1986.

___________, 'People and Events behind the "Science of Fractal Images"' in Heinz-Otto Peitgen and Dietmar Saupe, *The Science of Fractal Images*, Springer-Verlag, New York, 1988.

___________, 'Selected Topics in Mathematics, Physics and Finance Originating in Fractal Geometry', in M. Novak Miroslav, ed., *Thinking in Patterns: Fractals and Related Phenomena in Nature*, World Scientific, New Jersey, 2004.

___________, 'Stochastic Models for the Earth's Relief, the Shape and the Fractal Dimension of the Coastlines, and the Number-Area Rule for Islands', *Proceeding of the National Academy of Sciences*, vol. 72, no. 10, 1975, pp. 3825-3828.

___________, *The Fractal Geometry of Nature*, rev. ed., W.H. Freeman and Company, New York, 1983 [1977].

Mandelbrot Pictures, http://www.chem.vu.nl/~feenstra/mandel_gallery.html, (accessed 13/10/2007).

Mansfield, Edward D. and Jack Snyder, 'Democratization and War', *Foreign Affairs*, vol. 74, no. 3, 1995, pp. 79-97.

Manson, Steven M., 'Simplifying Complexity: a Review of Complexity Theory', *Geoforum*, vol. 32, no. 3, 2001, pp. 405-14.

Martin, Hans-Peter and Harald Schumann, *The Global Trap: Globalization and the Assault on Democracy and Prosperity*, trans., Patrick Camiller, Zed Books, London, 1997.

Mason, Andrew S., 'Plato on Necessity and Chaos', *Philosophical Studies*, vol. 127, no. 2, 2006, pp. 283-98.

Mathews, K. Michael, Michael C. White and Rebecca G. Long, 'Why Study the Complexity Sciences in the Social Sciences', *Human Relations*, vol. 52, no. 4, 1999, pp. 439-462.

McAfee, Kathleen, 'Neoliberalism on the Molecular Scale: Economic and Genetic Reductionism in Biotechnology Battles' Geoforum, vol. 34, 2003, pp. 203–19.

MccGwire, Michael, 'Shifting the Paradigm', *International Affairs*, vol. 78, no. 1, 2002, pp. 1-28.

McClelland, Charles A., 'Power and Influence' in John R. Champlin, ed., *Power*, Atherton Press, New York, 1971.

____________, *Theory and the International System*, Macmillan, New York, 1967.

McClelland, J. S., *A History of Western Political Thought*, Routledge, London and New York, 1996.

McFarlane, Thomas J., 'Nicholas of Cusa and the Infinite', *Integral Science*, March 2004, rev. ed., www.integralscience/cusa.html, (accessed 10/09/2006).

McGeough, Paul, 'The Giant Brought To Its Knees', *Sydney Morning Herald*, September 15, 2001, p. 11.

McHugh, James T. 'Last of the Enlightened Despots: A Comparison of President Mikhail Gorbachev and Emperor Joseph II', *The Social Science Journal*, vol. 32, no. 1, 1995, pp. 427-35.

McKeon, Richard, 'Philosophy and the Development of Scientific Methods', *Journal of the History of Ideas*, vol. 27, no. 1, 1966, pp. 3-22.

McKinnon, Susan and Sydel Silverman, eds, *Complexities: Beyond Nature and Nurture*, University of Chicago Press, Chicago, 2005.

McMullin, Ernan, 'The Impact of Newton's Principia on the Philosophy of Science', *Philosophy of Science*, vol. 68, no. 3, 2001, pp. 279-310.

Mearsheimer, John J., *The Tragedy of Great Power Politics*, W. W. Norton & Company, New York and London, 2003.

__________, 'Hans Morgenthau and the Iraq War: Realism Versus Neo-Conservatism', *Open Democracy: Free Thinking for the World*, 18 May 2005, http://www.opendemocracy.net/node/2522/pdf, date accessed 26/12/2007.

__________, 'Why We Will Soon Miss the Cold War', *The Atlantic Monthly*, vol. 266, no. 2, 1990, pp. 35-50.

Merrilee H. Salmon, 'Reasoning in the Social Sciences', *Syntheses*, vol. 97, no. 2, 1993, pp. 249-67.

Metz, Rudolf, *A Hundred Years of British Philosophy*, J. H. Muirhead, ed., trans. J. W. Harvey, T. E. Jessop and Henry Sturt, George Allen and Unwin Ltd, London, 1938.

Micklethwait, John and Wolldridge, Adrian, 'Rebuilding the Politics of Globalization', *The New York Times*, April 13, 2003, p. 6.

Midlarsky, Manus I., 'The Balance of Power as a "Just" Historical System', *Polity*, vol. 16, no. 2, pp. 181-200.

Mikulecky, Donald C., 'The Emergence of Complexity: Science Coming of Age or Growing Old?', *Computers and Chemistry*, vol. 25, 2001 pp. 341-8.

Miller, Cecilia (review) 'Vico: a Study of the 'New Science'', *History and Theory*, vol. 34, no. 1, 1995, pp. 132-8.

Miller, David L., 'Novelty and Continuity', *The Journal of Philosophy*, vol 47, no. 13, 1950, pp. 369-78.

Mills, C. Wright, *The Power Elite*, Oxford University Press, Oxford, 1956.

__________, *The Sociological Imagination*, Penguin Books, Harmondsworth, 1958.

Mills, William J., 'Positivism Reversed: The Relevance of Giambattista Vico', *Transactions of the Institute of British Geographers, New Series*, vol. 7, no. 1, 1982, pp. 1-14.

Mirowski, Philip, 'From Mandelbrot to Chaos in Economic Theory', *Southern Economic Journal*, vol. 57, no. 2, 1990, pp. 289-307.

__________, 'What's Kuhn Got to do With it?', *Social Epistemology*, vol. 17, no. 2&3, 2003, pp. 229-39.

Modelski, George, 'Evolutionary Paradigm for Global Politics', *International Studies Quarterly*, Vol. 40, No. 3, 1996, pp. 321-342.

Molloy, Seán, 'Realism: A Problematic Paradigm', *Security Dialogue*, vol. 34, no. 1, 2003, pp. 71-85.

__________, 'Truth, Power, Theory: Hans Morgenthau's Formulation of Realism', *Diplomacy and Statecraft*, vol 15, no. 1, 2004, pp. 1-34.

Montes, Leonidas, 'Newton's Real Influence on Adam Smith and its Context', *Cambridge Journal of Economics*, vol. 3, no. 4, 2008, pp. 555-76.

Montevideo Convention on the Rights and Duties of States, Dec . 26, 1933, 49 Stat . 3097, T .S . 881.

Moore, John E., 'Review Article: *'A More Beautiful City': Robert Hooke and the Rebuilding of London After the Great Fire*' by Michael Cooper, *Institute of Historical Research, March* 2005, http://www.history.ac.uk/reviews/paper/moore.html, (accessed 12/08/2007).

Morel, Benoit and Rangaraj Ramanujam, 'Through the Looking Glass of Complexity: The Dynamics of Organizations as Adaptive and Evolving Systems', *Organization Science*, vol. 10, no. 3, Special Issue: Application of Complexity Theory to Organization Science, 1999, pp. 278-93.

Morgenthau, Hans J., *Politics Among Nations: The Struggle for Power and Peace*, 4th ed., Alfred A. Knopf, New York, 1967 [1948].

__________, 'We Are Deluding Ourselves in Vietnam', *New York Times Magazine*, 18 April, 1965, pp. 24, 85-7.

Müller, Harald, 'Arguing, Bargaining and all that: Communicative Action, Rationalist Theory and the Logic of Appropriateness in International Relations', *European Journal of International Relations*, vol. 10, no. 3, 2004, pp. 395-435.

Müllerson, Rein A., *Ordering Anarchy: International Law and International Society*, Martinus Nijhoff Publishers, The Hague, 2000.

Myers, Denys P., 'The Bases of International Relations', *The American Journal of International Law*, vol. 31, no. 3, 1937, pp. 431-48.

Naím, Moisés, 'Why the World Loves to Hate America', *Financial Times*, December 7, 2001, p. 23.

Navon, Emmanuel, 'The 'Third Debate' Revisited', *Review of International Studies Revisited*, vol. 27, no. 4, 2001, pp. 611-625.

Nehamas, Alexander, 'The Sleep of Reason Produces Monsters', *Representations*, no. 74, 2001, pp. 37-54.

Nettl, J. P., 'The State as a Conceptual Variable, *World Politics*, vol. 20, no. 4, 1968, pp. 559-92.

Netz, Reviel, 'Introduction: The History of Early Mathematics – Ways of Re-Writing', *Science in Context*, vol. 16, no. 3, 2003, pp. 275-86.

Neufield, Mark, 'What's Critical About Critical International Relations Theory?' in Richard Wyn Jones, ed., *Critical Theory and World Politics*, Lynne Rienner Publishers, London and Boulder , 2001.

Newman, David V, 'Emergence and Strange Attractors, *Philosophy of Science*, vol. 63, no. 2, 1996, pp. 245-61.

Newman, Jay, 'Metaphysics and Absolute Presuppositions', *Man and World*, vol. 6, no. 3, 1973, pp. 290-92.

Newton, Isaac, *Mathematical Principles of Natural Philosophy and His System of the World*, [1687], trans. Andrew Motte [1729], trans. Revised, and supplied with an historical and explanatory appendix by Florian Cajori, University of California Press, Berkeley, 1934.

Nicholson, Michael, *Causes and Consequences in International Relations*, Pinter, London, 1996.

Nicoll, Alexander, 'West Faces Big Struggle In Age Of 'Asymmetric War'' *Financial Times*, October 5, 2001, p. 4.

Niebuhr, Reinhold, *Moral Man and Immoral Society: A Study in Ethics and Politics*, Westminster John Knox Press, Louisville, 2002 [1960].

Nielsen, Klaus and Stefan Kesting, 'Small is Resilient--the Impact of Globalization on Denmark', *Review of Social Economy*, vol. 61, no. 3, 2003, pp. 365-87.

Nincic, Miroslav, 'The United States, the Soviet Union, and the Politics of Opposites', *World Politics*, vol. 40, no. 4, 1988, pp. 452-475.

Norton-Taylor, Richard, 'Asymmetric Warfare: Military Planners are Only Beginning to Grasp the Implications of September 11 for Future Deterrence Strategy', *The Guardian*, October 3, 2001, p. 21.

___________, 'Iraq has Swollen Ranks of Al Qaida', *The Guardian*, October 16, 2003, p. 17.

Nowotny, Helga, 'The Increase of Complexity and Its Reduction: Emergent Interfaces between the Natural Sciences, Humanties and the Social Sciences', *Theory, Culture and Society*, vol. 22, no. 5, 2005, pp. 15-31.

Nye, Joseph, 'Limits of American Power', *Political Science Quarterly*, vol. 117, no. 4, 2002-2003, pp. 545-59.

Ó Riain, Seán, 'States and Markets in an Era of Globalization', *Annual Review of Sociology*, vol. 26, no. 1, 2000, 187-213.

Ohmae, Kenichi, *The Borderless World: Power and Strategy in the Interlinked Economy*, HarperPerennial, New York, 1991 [1990].

___________, *The End of the Nation State: The Rise of Regional Economies*, HarperCollins, London, 1995.

Onuf, Nicholas, *World of Our Making: Rules and Rule in Social Theory and International Relations*, University of South Carolina Press, Columbia, 1989.

Ormerod, Paul, *The Death of Economics*, Faber and Faber, London and Boston, 1994.

Orwell, George, 'London Letter to *Partisan Review*: December 1944', *Partisan Review*, 1945 in *The Collected Essays, Journalism and Letters of George Orwell: As I Please: 1943-1945*, vol. 3, Sonia Orwell and Ian Angus, eds, Secker and Walburg, London, 1968.

Overmyer, Daniel L., 'Folk-Buddhist Religion: Creation and Eschatology in Medieval China', *History of Religions*, vol. 12, no. 1, 1972, pp. 42-70.

Oxford English Dictionary, Oxford University Press, online at: http://dictionary.oed.com/

Pabottingi, Mochtar, 'Indonesia: Historicizing the New Order's Legitimacy Dilemma' in Muthiah Alagappa, *Political Legitimacy in Southeast Asia: The Quest for Moral Authority*, Stanford University Press, Stanford, 1995.

Pagels, Heinz R., *The Dreams of Reason: The Computer and the Rise of Complexity*, Simon and Schuster, New York, 1998.

Parsons, Talcott, 'On the Concept of Political Power', *Proceedings of the American Philosophical Society*, vol. 107, no. 3, 1963, pp.232-62,

___________, *Politics and Social Structure*, The Free Press, New York, 1969.

Patey, Douglas Lane, 'Swift's Satire on "Science" and the Structure of Gulliver's Travels', *ELH*, vol. 58, no. 4, 1991, pp. 809-39.

Patomäki, Heikki and Colin Wight, 'After Postpositivism? The Promises of Critical Realism', *International Studies Quarterly*, vol. 44, pp. 213-37.

Paul, Joel R., 'The New Movements in International Economic Law', *American University Journal of International Law and Policy*, vol. 10, no. 2, 1994-1995, pp. 607-17.

Peitgen, Heinz-Otto, and Peter H. Richter, *The Beauty of Fractals: Images of Complex Dynamical Systems*, Springer-Verlag, Berlin, 1986.

Peitgen, Heinz-Otto, Hartmut Jürgens and Dietmar Saupe, *Chaos and Fractals: New Frontiers of Science*, Springer-Verlag, New York, 1992.

Pelikan, Jaroslav, *What Has Athens to Do with Jerusalem?: Timaeus and Genesis in Counterpoint*, University of Michigan Press, Ann Arbor, 1997.

Percivall, George S., 'Application of Complexity Theories to Evolutionary System Development', Francis Heylighen, Johan Bollen and Alexander Riegler, eds, *The Evolution of Complexity: The Violet Book of Einstein meets Magritte*, Kluwer Academic Publishers, Dordrecht, 1999.

Petras, James and Veltmeyer, Henry, 'Globalization Unmasked: The Dynamics and Contradictions of Global Capitalism' in *Globalization and Change: The Transformation of Global Capitalism*, Lexington Books, Langham, 2005.

Peters, Edgar E., *Fractal Market Analysis: Applying Chaos Theory to Investment and Economics*, John Wiley & Sons, New York, 1994.

Petrović, Edit, 'Ethnonationalism and the Dissolution of Yugoslavia', in Joel Martin Halpern and David A. Kideckel, eds, *Neighbors at War: Anthropological Perspectives on Yugoslav Ethnicity, Culture, and History*, ed., Penn State University Press, University Park 2000.

Phelan, Steven E., 'What is Complexity Science, Really?', *Emergence*, vol. 3, no. 1, 2001, pp. 120-36.

Philip, Pradeep, 'Transcendental Realism – A Foundation for Evolutionary Economics', *International Journal of Social Economics*, vol. 22, no. 12, 1995, pp. 19-35.

Philpott, Daniel, 'Sovereignty: An Introduction and Brief History', Journal of *International Affairs*, vol. 48, no. 2, 1995, pp. 353-368.

Pigliucci, Massimo, "Chaos and Complexity", *Skeptic*, vol. 8, no. 3, 2000, pp.62-71

Pil Rhee, Yong, 'Chaos and order through fluctuations in global capitalism in the twenty-first century', *Systems Research and Behavioral Science*, vol. 20, no. 5, 2003 pp. 427-433.

___________, 'Complex Systems Approach to the Study of Politics', *Systems Research and Behavioural Science*, vol. 17, no. 6, 2000, pp. 487-491.

Plamentatz, John, *Man and Society: A Critical Examination of Some Important Social and Political Theories from Machiavelli to Marx*, vol. 1, Longman Group, London, 1963.

Polanyi, Michael, 'Scientific Outlook: Its Sickness and Cure', *Science*, vol. 125, no. 3246, 1957, pp. 480-484.

Pompa, Leon, *Human Nature and Historical Knowledge: Hume, Hegel and Vico*, Cambridge University Press, Cambridge, 1990.

___________, *Vico: A Study of the 'New Science'*, Cambridge University Press, Cambridge, 1990.

Pool, Robert, 'Chaos Theory: How Big an Advance?', *Science*, vol. 245, no. 4913, 1989, pp. 26-8.

Popkin, Jeremy D., 'Political Communication in the German Enlightenment: Gottlob Benedikt von Schirach's Politische Journal' *Eighteenth-Century Life*, vol. 20 no. 1, 1996 pp. 24-41.

Prigogine, Ilya and Isabelle Stengers, *Order Out of Chaos: Man's New Dialouge with Nature*, New Science Library, Boulder, 1984.

Prigogine, Ilya, 'The Arrow of Time' in V. G. Gurzadyem and R. Ruffini, eds, *The Chaotic Universe*, Advance Series in Astrophysics and Cosmology, vol. 10, World Scientific Publications, Singapore, 2000.

___________, *The End of Certainty: Time, Chaos, and the New Laws of Nature*, The Free Press, New York, 1997.

___________, 'What is Entropy?', *Naturwissenscaften*, vol. 76, no. 1, 1989, pp. 1-9.

Purdum, Todd S., 'The Brains Behind Bush's War', *New York Times*, February 1, 2003, p. A19.

Pye, Lucian W., *Asian Power and Politics: The Cultural Dimensions of Authority*, The Belknap Press of Harvard University, Cambridge and London, 1985.

Randle, Robert F., 'Review Article: *Theory of International Politics* by Kenneth Waltz', *Political Science Quarterly*, vol. 95, no. 1, 1980, pp. 136-137.

Ranson, Baldwin, 'Rival Economic Epistemologies: The Logics of Marx, Marshall and Keynes', *Journal of Economic Issues*, vol. 14, no. 1, 1980, pp. 77-98.

Rasch, William, 'Theories of Complexity, Complexities of Theory: Habermas, Luhmann, and the Study of Social Systems', *German Studies Review*, vol. 14, no. 1, 1991, pp. 65-83.

Recchia, Stefano, 'Restraining Imperial Hubris: The Ethical Bases of Realist International Relations Theory', *Constellations*, vol. 14, no 4, 2007, p. 531-56.

Rechenberg, Helmut, 'Quanta and Quantum Mechancis', Laurie M. Brown, Abraham Pais and A. B. Pippard, eds, *Twentieth Century Physics*, vol. 1 American Institute of Physics Press, Salem, 1995.

Reeves, Jesse S., 'International Society and International Law', *The American Journal of International Law*, vol. 15, no. 3, 1921, pp. 361-374.

Rengger, Nicholas, *International Relations, Political Theory, and the Problem of Order*: *Beyond International Relations Theory?*, Routledge, London and New York, 1999.

___________, 'Political Theory and International Relations: Promised Land or Exit From Eden?', *International Affairs*, vol. 76, no. 4, 2000, p. 755-70.

___________, 'Realism, Tragedy, and the Anti-Pelagian Imagination in International Political Thought' in Michael C. Williams, ed., *Realism Reconsidered: The Legacy of Hans J. Morgenthau in International Relations*, Oxford University Press, Oxford, 2007.

Rice, Condoleezza, 'A Balance of Power That Favors Freedom', Wriston Lecture, Manhattan Institute For Policy Research, New York City, October 1, 2002, http://www.manhattan-institute.org/html/wl2002.htm, (accessed 16/03/2008).

___________, 'Remarks at the Institut d'Etudes Politiques de Paris - Sciences Po' Paris, France, February 8, 2005, US Department of State, http://www.state.gov/secretary/rm/2005/41973.htm, (accessed 16/03/2008).

Richards, Diana, 'A Chaotic Model of Power Concentration in the International System', *International Studies Quarterly*, vol. 37, no. 1, 1993, pp. 55-72.

Richardson, James L., 'International Relations and Cognate Disciplines: From Economics to Historical Sociology' in Robert M. A. Crawford, and Darryl S. L. Jarvis, eds, *International Relations – Still an American Social Science: Towards Diversity in International Thought*, State University of New York Press, Albany, 2001.

Richardson, Robert C., 'Complexity, Self-Organization and Selection' Biology and Philosophy, vol. 16, no. 5, 2001, pp. 655-83.

Rihani, Samir, 'Complexity Theory: A New Framework for Development in the Offing', *Progress in Development Studies*, vol. 5, no. 1, 2005, pp. 55-61.

Robison, Richard, Kevin Hewinson and Garry Rodan, 'Political Power in Industrialising Capitalist Societies: Theoretical Approaches' in Kevin Hewinson, Richard Robison, and Garry Rodan, eds, *Southeast Asia in the 1990s: Authoritarianism, Democracy and Capitalism*, Allen and Unwin, St Leonards, 1993.

Rogers, G. A. J., 'Descartes and the Method of English Science', *Annals of Science*, vol. 29, no. 3, 1997, pp. 237-55.

Roochnik, David, *Retrieving the Ancients: An Introduction to Greek Philosophy*, Blackwell Publishing, Malden, 2004.

Rosenau, James N., 'A Pre-Theory Revisited: World Politics in an Era of Cascading Interdependence', *International Studies Quarterly*, vol. 28, no. 3, 1984, pp. 245-305.

__________, 'Change, Complexity, and Governance in Globalizing Space' in John Pierre, ed., *Debating Governance: Authority, Steering and Democracy*, Oxford University Press, Oxford, 2000.

__________, *Distant Proximities: Dynamics Beyond Globalization*, Princeton University Press, Princeton, 2003.

__________, 'Illusions of Power and Empire', *History and Theory*, vol 44 (theme issue), 2005, pp. 73-87.

__________, 'Many Damn Things Simultaneously' in David S. Albert and Thomas J. Czerwinski, eds, *Complexity, Global Politics and World Affairs*, University Press of the Pacific, Honolulu, 1997.

__________, 'Muddling, Meddling and Modelling: Alternative Approaches to the Study of World Politics in an Era of Rapid Change', *Millennium: Journal of International Studies*, vol. 8, no. 2, 1979, pp. 130-44.

__________, 'Patterned Chaos in Global Life: Structures and Process in the Two Worlds of World Politics', *International Political Science Review*, vol. 9, no. 4, 1988, pp. 327-64.

__________, 'The Future of Politics', *Futures*, vol. 31, no. 9-10, 1999, pp. 1005-16.

__________, *The Study of World Politics: Theoretical and Methodological Challenges*, vol. 1, Routledge, New York, 2006.

__________, *Turbulence in World Politics: a Theory of Change and Continuity*, Princeton University Press, Princeton, 1990.

Rosenberg, Alexander, 'Hume and the Philosophy of Science', in Fate Norton, David, ed., *The Cambridge Companion to Hume*, Cambridge University Press, Cambridge, 1993.

Rosser Jr., J. Barkley, 'Aspects of dialectics and non-linear dynamics', *Cambridge Journal of Economics*, vol. 24, no. 3, 2000, pp. 311-24.

Roth, Paul A. and Thomas A. Ryckman, 'Chaos, Clio, and Scientific Illusions of Understanding', *History and Theory*, vol. 34, no. 1, pp 30-44.

Rothstein, Edward, 'Lacking a Center, Terrorist Networks Are Hard to Find, Let Alone Fight', *New York Times*, October 20, 2001, p. A11.

Rousseau, Jean-Jacques, *Of the Social Contract or Principles of the Political Right* in the *Social Contract and Other Later Political Writings*, Victor Gourovitch, ed., Cambridge University Press, Cambridge, 1997 [1762].

___________, *State of War* in the *Social Contract and Other Later Political Writings*, Victor Gourovitch, ed., Cambridge University Press, Cambridge, 1997.

Roxborough, Ian, 'Globalization, Unreason and the Dilemmas of American Military Strategy', *International Sociology*, vol 17, no. 3, 2002, pp. 339-59.

Rubin, Trudy, 'Hard To Combat Asymmetric Warfare', *The Times Union*, September 14, 2001, p. A19.

Ruggie, John Gerald, 'The False Promise of Realism', *International Security*, vol. 20, no. 1, 1995. pp. 62-70.

___________, 'International Structure and International Transformation: Space, Time, and Method' in Ernst-Otto Czempiel and James Rosenau, eds, *Global Changes and Theoretical Challenges: Approaches to World Politics for the 1990s*, Lexington Books, Lexington, 1989.

___________, 'Territoriality and Beyond: Problematizing Modernity in International Relations', *International Organisation*, vol. 47, no. 1, 1993, pp. 139-174.

Russell, Bertrand, *History of Western Philosophy*, 2nd ed., Unwin University Books, London, 1961.

___________, *Power: A New Social Analysis*, Allen and Unwin, London, 1983 [1938].

___________, 'The Forms of Power' in Steven Lukes, ed., *Power*, Basil Blackwell, Oxford, 1986.

Safire, William, 'The Way We Live Now', *The New York Times*, October 21, 2001, p. 30.

Said, Edward W., *Orientalism*, Penguin Books, London, 1991 [1978].

___________, 'The Clash of Ignorance', *The Nation*, vol. 273, no. 12, October 22, 2001, pp. 11-13.

Sala, Nicoletta, 'Fractal Geometry in the Arts: An Overview Across Different Cultures', in Miroslav M. Novak, ed., *Thinking in Patterns: Fractals and Related Phenomena in Nature*, World Scientific, New Jersey, 2004.

Sampson, Aaron Beers, 'Tropical Anarchy: Waltz, Wendt, and the Way We Imagine International Politics', *Alternatives*, vol. 27, no. 1, 2002, pp. 429-57.

Sanders, T. Irene, 'To Fight Terror, We Can't Think Straight', *Washington Post*, Sunday, May 5, 2002, p. B02

Saperstein, Alvin M., 'Alliance Building Versus Independent Action: A Nonlinear Modeling Approach to Comparative International Stability', *The Journal of Conflict Resolution*, vol. 36, no. 3, 1992, pp. 518-45.

___________, 'The Prediction of Unpredictability: Applications of the New Paradigm of Chaos in Dynamical Systems to the Old Problem of the Stability of a System of Hostile Nations' in L. Douglas Kiel and Euel Elliot, eds, *Chaos Theory in the Social Sciences: Foundations and Applications*, University of Michigan Press, Ann Arbor, 1996.

Sardar, Ziauddin and Iwona Abrams, *Introducing Chaos*, Icon Books, Cambridge, 1999 [1998].

Sarkar, Palash, 'A Brief History of Cellular Automata', *ACM Computing Surveys*, vol. 32, no. 1, 2000, pp. 80-107.

Saul, John Ralston, *Voltaire's Bastards: The Dictatorship of Reason in the West*, Penguin Books, London, 1992.

Sawyer, R. Keith, 'Simulating Emergence and Downward Causation in Small Groups', in Moss, S. and Davidsson, P., eds., *Multi-Agent-Based Simulation*, Springer Berlin, Heidelberg, 2000.

___________, 'The Emergence of Creativity', *Philosophical Psychology*, vol. 12, no. 4, 1999, pp. 447-69.

Schaffner, Kenneth F., 'Reductionism, Complexity and Molecular Medicine: Genetic Chips and the 'Globalization' of the Genome', in D. L. Hull and M. van Regenmortel, eds, *Promises and Limits of Reductionism in the Biomedical Sciences*, John Wiley and Sons, New York, 2002.

Schmidt Brian C. and Michael C., Williams, 'The Bush Doctrine and the Iraq War: Neoconservatives Versus Realists', *Security Studies*, vol. 17, no. 2, 2008, pp. 191-220.

Schmidt, Brian C., 'On the History and Historiography of International Relations' in Walter Carlsnaes, Thomas Risse and Beth A. Simmons, eds, *The Handbook of International Relations*, Sage, Thousand Oaks, 2002.

___________, *The Political Discourse of Anarchy: A Disciplinary History of International Relations*, State University of New York Press, Albany, 1998.

Scholte, Jan Aart, 'Global Capitalism and the State', *International Affairs*, vol. 73, no. 3, 1997, pp. 427-452.

Schrödinger, Erwin, 'Are There Quantum Jumps? Part I', *The British Journal for the Philosophy of Science*, vol. 3, no. 10, 1952, pp. 109-23.

Schweller, Randall L., 'The Problem of International Order Revisited', *International Security*, vol. 26, no. 1, 2001, pp 161-186.

Scott, Alwyn, 'Reductionism Revisited', *Journal of Consciousness Studies*, vol. 11, no. 2, 2004, pp. 51-68.

Shapiro, Alan E. 'Twenty-Nine Years in the Making: Newton's Opticks', *Perspectives on Science*, vol. 16, no. 4, 2008, pp. 417-38.

Sharrock, Wes. W., and Rupert S. Reed, *Kuhn: Philosopher of Scientific Revolutions*, Polity Press, Cambridge, 2002.

Sheehan, Michael, *The Balance of Power: History and Theory*, Routledge, London and New York, 1996.

Shelley, Mary Wollstonecraft, *Frankenstein: or, The Modern Prometheus*, ed., M. K. Joseph, Oxford University Press, New York, 1980.

Shermer, Michael 'Exorcising Laplace's Demon: Chaos and Antichaos, History and Metahistory', *History and Theory*, vol. 34, no. 1, 1995, pp. 59-83.

Shiller, Robert, 'Feedback and Chatter Behind Global Booms and Busts', *The Age*, August 31, 2009, p. 6.

Shimko, Keith L., 'Realism, Neorealism, and American Liberalism', *Review of Politics*, vol. 54, no. 2, 1992, pp. 281-301.

Sijuwade, Philip O., 'Recent Trends in the Philosophy of Science: Lessons for Sociology', *Journal of Social Sciences*, vol. 14, no. 1, 2007, pp. 53-64.

Simon, Steven, 'The New Terrorism: Securing the nation against a Messianic Foe', *Brookings Review*, vol. 21, no. 1, 2003, pp. 18-24.

Singer, J. David, 'The Level-of-Analysis Problem in International Relations', *World Politics*, Vol. 14, No. 1, 1961, pp. 77-92

Skinner, Andrew S., 'The Shaping of Political Economy in the Enlightenment', *Scottish Journal of Political Economy*, vol. 37, no. 2, 1990, pp. 145-65.

Smeeding, Timothy M. and Lee Rainwater, 'Comparing Living Standards Across Nations: Real Incomes at the Top, The Bottom and the Middle', Luxembourg Income Study Working Paper No. 266.

Smith, Adam, *An Inquiry Into the Nature and Causes of the Wealth of Nations*, R.H. Campbell and A.S. Skinner, eds, Clarendon Press, Oxford, 1979 [1776].

___________, *Lectures on Jurisprudence*, R.L. Meek, D.D. Raphael and L.G. Stein, eds, Oxford University Press, Oxford, 1978.

___________, *The Theory of Moral Sentiments*, D. D. Raphael and A. L. Macfie, eds, Clarendon Press, Oxford, 1976 [1759]

Smith, John A., and Chris Jenks, *Qualitative Complexity: Ecology Cognitive Process and the Re-Emergence of Structure in Post Humanist Social Theory*, Routledge, London, 2006.

Smith, Steve 'Historical Sociology and International Relations Theory', in Stephen Hobden and John M. Hobson, eds, *Historical Sociology of International Relations*, Cambridge University Press, 2002.

___________, 'The End of the Unipolar Moment: September 11 and the Future of World Order', *International Relations*, vol. 16, no. 2, 2002, pp. 171–184.

___________, 'Singing Our World into Existence: International Relations Theory and September 11', *International Studies Quarterly*, vol. 48, no. 3, 2004, pp. 499-515.

___________, 'Wendt's World', *Review of International Studies*, vol. 26, no. 1, 2000, pp. 151-63.

Smolin, Lee, 'A Theory of the Whole Universe', '*The Third Culture: Beyond the Scientific Revolution*, Simon & Schuster, 1995, http://www.edge.org/documents/ThirdCulture/z-Ch.17.html, (accessed 17/02/2006.)

Soffer, Walter, 'Descartes Rejection of the Aristotelian Soul', in Georges J. D. Moyal, ed., *René Descartes: Critical Assessments*, vol. 3, Routledge, New York, 1991.

Somerville, Margaret, 'Reductionism v Complexity: A Canary in the Bioethics Crossfire', *Quadrant*, vol. 45, no. 7-8, 2001, p. 30-5.

Sparks, Chris, 'Liberalism, Terrorism and the Politics of Fear', *Politics*, vol. 23, no. 3, 2003, pp. 200-206.

Spencer, Quayshawn, 'Do Newton's Rules of Reasoning Guarantee Truth … Must They?', *Studies in History and Philosophy of Science*, vol. 35, no. 4, 2004, pp. 759-782.

Srawooth, Paitoongpong, 'Social Implications of the Asian Economic Crisis in Thailand, Indonesia, Malaysia and the Philippines: Synthesis Report', *TDRI Quarterly Review*, vol. 16, no. 1, 2001, pp. 3-14.

Stachel, John, 'History of Relativity' in Brown, Laurie M.; Pais, Abraham and; Pippard, A. B., eds, *Twentieth Century Physics*, vol. 1 American Institute of Physics Press, Salem, 1995.

Stäheli, Urs, 'The Outside of the Global', *The New Centennial Review*, vol. 3, no. 2, 2003, pp. 1-22.

Stambovsky, Phillip, 'Metaphor and Historical Understanding', *History and Theory*, vol. 27, no. 2, 1988, pp. 125-134.

Steel, R., 'The Hard Questions: Paradigm Regained', *The New Republic*, vol. 215, no. 27, 1996, p. 25.

Stempel, Daniel, 'Angels of Reason: Science and Myth in the Enlightenment' *Journal of the History of Ideas*, vol. 36, no. 1, 1975, pp. 63-78.

Stewart, Ian, 'Portrait of Chaos' in Nina, Hall ed., *The New Scientist Guide to Chaos*, Penguin Books, London, 1991.

Stewart, Peter 'Complexity Theories, Social Theory, and the Question of Social Complexity, *Philosophy of the Social Sciences*, vol. 31, no. 3, 2003, pp. 323-60.

Thayer, Bradley A., *Darwin and International Relations: On the Evolutionary Origins of War and Ethnic Conflict*, Kentucky University Press, Kentucky, 2004.

Thompson, Mark, 'A Long Career of Marching with the Cross: The Boykin Affair', *Time*, vol. 163, no. 14, November 3, 2003, p. 30.

Thomson, James W., 'Globalization: Obsession or Necessity?', *Business and Society Review*, vol. 104, no. 4, 1999, pp. 397-405

Toulmin, Stephen, *Foresight and Understanding: An Enquiry into the Aims of Science*, Hutchinson & Co., London, 1961.

___________, *Human Understanding*, Clarendon Press, Oxford, 1972.

___________, 'The Idol of Stability', The Tanner Lectures on Human Values, delivered at the University of Southern California, February, 1998, pp. 325-54.

Trigg, Roger, *Rationality and Science: Can Science Explain Everything?*, Blackwell Publishers, Oxford, 1993.

Tucker, William, 'Complex Questions: the New Science of Spontaneous Order', *Reason*, vol. 27, no. 8, 1996, pp. 34-8.

Turner, Jonathan H., 'Durkheim's And Spencer's Principles of Social Organization: A Theoretical Note' in John Offer, ed., *Herbert Spencer: Critical Assessments of Leading Sociologists*, vol. 2, Routledge, London, 1999.

Urry, John, *Global Complexity*, Polity Press, Cambridge, 2003.

__________, 'The Complexity of the Global', *Theory, Culture and Society*, vol. 22, no. 5, 2005, pp. 235-54.

__________, 'The Complexity Turn', *Theory, Culture and Society*, vol. 22, no. 5, 2005, pp. 1-14.

van Fraasen, Bas C., *The Scientific Image*, Clarendon Press, Oxford, 1980.

Vasquez, John, 'Kuhn versus Lakatos? The Case for Multiple Frames in Appraising International Relations Theory' in Colin Elman and Miriam Fendius Elman, eds, *Progress in International Relations Theory: Appraising the Field,* Massachusetts Institute of Technology Press, Cambridge, 2003.

__________, *The Power of Power Politics: From Classical Realism to Neotraditionalism*, Cambridge University Press, Cambridge, 1998.

__________, 'World Politics Theory' in Mary Hawkesworth and Maurice Kogan, eds, *Encyclopaedia of Government and Politics*, vol. 2, Routledge, London and New York, 1992.

Verschuren, Piet J. M., 'Holism versus Reductionism in Modern Social Science Research', *Quality and Quantity*, vol. 35, no. 4, 2001, pp. 389-405.

Vico, Giambattista, *The New Science*, 3rd ed., eds and trans Thomas Goddard Bergen and Max Harold Fisch, Cornell University Press, Ithaca, 1968 [1744].

__________, *Vico: Selected Writings*, Leon Pompa, ed. (and trans.), Cambridge University Press, Cambridge, 1982.

Vogel, Joachim ,'Income and Material Living Standards', *Social Indicators Research*, vol. 64, no. 3, 2003, pp. 437-69.

Voltaire, 'Letter XIV on Des Cartes and Sir Isaac Newton' in *Letters Concerning the English Nation*, Peter Davies, London, 1926.

Wachtel, Andrew Baruch, *Making a Nation, Breaking a Nation: Literature and Cultural Politics in Yugoslavia*, Stanford University Press, Stanford, 1998.

Wade, Robert, 'Gestalt Shift: From "Miracle" to "Cronyism" in the Asian Crisis', DESTIN Working Paper Series, Development Studies Institute, London School of Economics and Political Science, paper no 02-25, 2002.

Wæver, Ole, 'Four Meanings of International Society: A Trans-Atlantic Dialogue, in Barbara Roberson, ed., *International Society and the Development of International Relations Theory*, Rev. ed., Continuum, London, 2002

Waldrop, M. Mitchell, *Complexity: The Emerging Science at the Edge of Order and Chaos*, Simon and Schuster, New York, 1992.

Wallerstein, Immanuel, *Unthinking Social Science: The Limits of Nineteenth Century Paradigms*, 2nd Edition, Temple University Press, Philadelphia, 2001.

Walt, Stephen M., 'International Relations: One World, Many Theories', *Foreign Policy*, no. 110, 1998, pp. 29-46.

__________, 'Keeping the World "Off-Balance": Self Restraint and US Foreign Policy' in G. John Ikenberry, ed., *America Unrivaled: The Future of the Balance of Power*, Cornell University Press, Ithaca and London, 2002.

__________, *The Origin of Alliances*, Cornell University Press, Ithaca and London, 1987.

Waltz, Kenneth N., 'Evaluating Theories', *American Political Science Review*, vol. 91, no. 4, 1997, pp. 913-917.

__________, *Man, the State and War: A Theoretical Analysis*, Columbia University Press, New York, 1959.

__________, 'Structural Realism after the Cold War', *International Security*, vol. 25, no. 1, 2000, pp. 5-41.

__________, *Theory of International Politics*, Addison-Wesley, Reading, 1987.

Warren, Mark E., 'What is Political Theory/Philosophy', *PS: Political Science and Politics*, vol. 22, no. 3, 1989, pp. 606-12.

Weber, Martin 'Engaging Globalization: Critical Theory and Global Political Change', *Alternatives* vol. 27, 2002, pp. 301-325.

Weber, Max, *The Methodology of the Social Sciences*, trans and eds, Edward A. Shils and Henry A. Finch, The Free Press, Glencoe, 1949.

Weiss, Thomas G., 'What Happened to the Idea of World Government', *International Studies Quarterly*, vol. 53, no. 2, 2009, pp. 253-71.

Weisstein, Eric W., 'Bifurcation', *MathWorld--A Wolfram Web Resource*, http://mathworld.wolfram.com/Bifurcation.html, (accessed 10/12/2007).

Wendt, Alexander and Raymond Duvall, 'Institutions and International Order' in Ernst-Otto Czempiel and James Rosenau, eds, *Global Changes and Theoretical Challenges: Approaches to World Politics for the 1990s*, Lexington Books, Lexington, 1989

Wendt, Alexander, 'Anarchy is What States Make of it: the Social Construction of Power Politics', *International Organization*, vol. 42, no. 2, 1992, pp. 384-96.

__________, 'Bridging the Theory/Meta-Theory Gap in International Relations', *Review of International Studies*, vol. 17, no. 4, 1991, pp. 383-92.

__________, 'Collective Identity Formation and the International State', *American Political Science Review*, vol. 88, no. 2, 1994, pp. 384-396.

__________, 'Constructing International Politics', *International Security*, vol. 20, no. 1, 1995, pp. 71-85.

__________, 'How Not to Argue Against State Personhood: a Reply to Lomas', *Review of International Studies*, vol. 31, no 2, 2005, pp. 357-360.

__________, 'On Constitution and Causation in International Relations', *Review of International Studies*, vol. 25, no. 5, 2001, pp. 101-118

__________, 'The Agent-Structure Problem in International Relations Theory', *International Organization*, vol. 41, no. 3, 1987, pp. 335-370.

__________, 'The State as Person in International Theory', *Review of International Studies*, vol. 30, no. 2, 2004, pp. 289-316.

__________, 'Why a World State is Inevitable', *European Journal of International Relations*, vol. 9, no. 4, 2003, pp. 491-542.

__________, *Social Theory of International Politics*, Cambridge University Press, Cambridge, 1999.

Wertheim, Margaret, 'New World Disorder: What Now?', *LA Weekly*, November 2-8, 2001 p. 13.

West, Bruce J., and Bill Deering, *The Lure of Modern Science: Fractal Thinking, World Scientific*, Singapore, 1995.

White, Michael, Isaac *Newton: the last sorcerer*, Fourth Estate, London, 1997.

Whittaker, David, *The Terrorism Reader*, 2nd ed., Routledge, New York, 2003.

Whittaker, Thomas, *Reason: A Philosophical Essay with Historical Illustrations*, Greenwood Press Publishers, Westport, 1968 [1934].

Wight, Colin, 'Philosophy of Science and International Relations', in Walter Carlsnaes, Thomas Risse and Beth A. Simmons, eds, *The Handbook of International Relations*, Sage, Thousand Oaks, 2002.

__________, 'State Agency: Social Action Without Human Activity', *Review of International Studies*, vol. 30, no. 3, 2004, pp. 269-280.

__________, 'They Shoot Dead Horses Don't They? Locating Agency in the Agent-Structure Problematique', *European Journal of International Relations*, vol. 5, no. 1, 1999, pp. 109-42.

Wight, Martin, *Four Seminal Thinkers in International Theory: Machiavelli, Grotius, Kant, Mazzini,* Gabrielle Wight and Brian Porter, eds, Oxford University Press, Oxford, 2005.

Williams, Michael C., 'Hobbes and International Relations: A Reconsideration', *International Organization*, vol. 50, no. 2, 1996, pp. 213-36.

__________, 'What is the National Interest? The Neoconservative Challenge in IR Theory', *European Journal of International Relations*, vol. 11, no. 3, 2005, pp. 307-37.

__________, 'Why Ideas Matter in International Relations: Hans Morgenthau, Classical Realism, and the Moral Construction of Power Politics', *International Organization*, vol. 58, no. 4, 2004, pp. 633-65.

Witt, Ulrich, 'Self-organization and Economics – What is New?', *Structural Change and Economic Dynamics*, vol. 8, no. 4, 1997, pp. 489-507.

Wohlforth, William C., 'Reality Check: Revising Theories of International Politics in Response to the End of the Cold War', *World Politics*, vol. 50, no. 4, 1998, pp. 650-680.

Wolfers, Arnold, 'Actors in International Politics' in William T. R. Fox, ed., *Theoretical Aspects of International Relations*, University of Notre Dame Press, Notre Dame, 1959.

__________, *Discord and Collaboration: Essays on International Politics*, The John Hopkins Press, Baltimore, 1962.

Wolfram, Stephen, *A New Kind of Science*, Wolfram Media, Champaign, 2002.

Wolin, Sheldon S., 'Hume and Conservatism', *American Political Science Review*, vol. 48, no. 4, 1954, pp. 999-1016.

Wright, Crispin, 'Scepticism and Dreaming: Imploding the Demon', *Mind*, vol. 100, no. 1, 1991, pp. 87-116.

Wyatt-Walter, Andrew, 'Adam Smith and the Liberal Tradition in International Relations', *Review of International Studies*, vol. 22, no. 1, 1996, pp. 5-28.

Young, John T., 'Isaac Newton's Alchemical Notes in the Royal Society', *Notes and Records of the Royal Society*, vol. 60, no. 1, 2006, pp. 25-34.

Young, T. R., 'Chaos Theory and Social Dynamics: Foundations of a Post Modern Science' in R. Robertson and A. Combs, eds., *Chaos Theory in Psychology and the Life Sciences*, Lawrence Erlbaum Associates, New Jersey, 1995.

Yu, David C., 'The Creation Myth and Its Symbolism in Classical Taoism', *Philosophy East and West*, vol. 31, no. 4, 1981, pp. 479-500.

Zafirovski, Milan, 'The Rational Choice Generalization of Neoclassical Economics Reconsidered: Any Theoretical Legitimation for Economic Imperialism?', *Sociological Theory*, vol. 18, no. 3, 2000, pp. 448-71.

Zamagni, Stefano, 'Economic Reductionism as a Hindrance to the Analysis of Structural Change: Scattered Notes', *Structural Change and Economic Dynamics*, vol. 11, no. 1-2, 2000, pp. 197-208.

Zanini, Michele and Sean J.A. Edwards, 'The Networking of Terror in the Information Age' in John Arquilla and David F. Ronfeldt, eds, *Networks and Netwars: The Future of Terror, Crime, and Militancy*, Rand, Santa Monica, 2001.

Zhang, Wei-Bin, 'Theory of Complex Systems and Economic Dynamics', *Nonlinear Dynamics, Psychology, and Life Sciences*, vol. 6, no. 2, 2002, pp. 83-101.