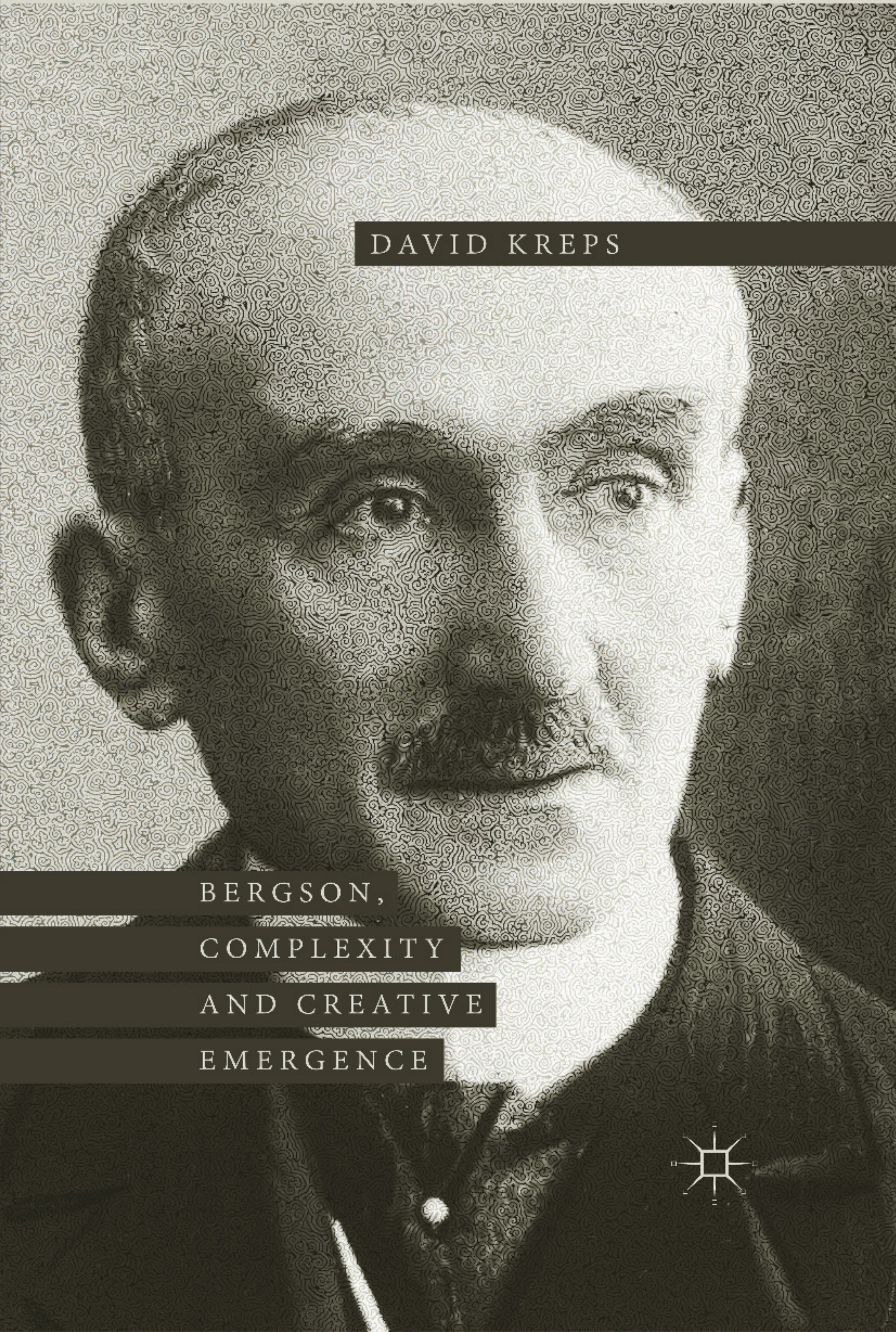
DAVID KREPS

BERGSON, COMPLEXITY AND CREATIVE EMERGENCE



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David Kreps

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List of Illustrations

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Abbreviations of Bergson's Works

Bergson's works are referred to in the references by their abbreviations, as set out below, and page numbers refer to the editions listed below:

TFW Bergson, H. (2005[1889]) *Time and Free Will.* Adamant Media Elibron Classics reproduction of 1913 edition, trans. F.L. Pogson, New York: George Allen and Unwin

MM Bergson, H. (2004[1896]) *Matter and Memory*, trans. Nancy Margeret Paul and W. Scott Palmer 1912. London: Dover

IM Bergson, H. (1946[1903]) 'An Introduction to Metaphysics' (Essay in *Revue de Métaphysique et de Morale* January 1903) in *The Creative Mind,* trans. Mabelle L. Andison, New York: Philosophical Library

CE Bergson, H. (1944[1907]) *Creative Evolution,* trans. Arthur Mitchell, with a Foreword by Irwin Edman. New York: Random House Modern Library

ME Bergson, H. (1975[1920]) *Mind–Energy,* trans. H. Wildon Carr, Westport CT: Greenwood Press

DS Bergson, H. (1965[1922]) *Duration and Simultaneity.* Reproduction of 1929 4th edition, trans. Leon Jacobson, New York: Bobbs-Merrill Company

TSMR Bergson, H. (2006[1935]) *The Two Sources of Morality and Religion.* Notre Dame, IN: University of Notre Dame Press

CM Bergson, H. (1946) *The Creative Mind*, trans. Mabelle L. Andison, New York: Philosophical Library

1
Introduction

This is a book about evolution.

It may seem that the arguments about what evolution *is* have all been played out – over a hundred years ago – and that Darwin's version of events is today challenged only by the religiously devout. But the truth is that Darwin's version of events is itself challenged by the orthodox neo-Darwinism popularised by such figures as Dawkins, and that not only is there a long tradition of other ideas about evolution, there is today a very strong case to suggest that Darwin's was only part of the story – and not even the most important part at that.

This is a book about two alternatives to orthodox Darwinism that turn out to be both closely related and mutually reinforcing – and which both uphold Darwin's version of events as a secondary force. One derives from late 19th/early 20th century French philosophy; the other from contemporary complex evolutionary biology. I set out in this book to describe both these alternatives in terms understandable by as wide a range of scholars as I am able: both to inform those aware of philosophy concerning the developments in environmental biology; and, perhaps more importantly, vice versa. In the process I will also need to tell the history of our understanding and use of the term 'system': it turns out that this is crucial to how we understand evolution.

The philosopher who is the focus of our attention is Henri Bergson (1859–1941). Bergson's ideas are enjoying something of a revival in various circles. He has, in the past, had many critics; and there remain – in this author's eyes, at least – some elements of his work that have not stood the test of time (for example, elements of the second part of his last work, *Two Sources of Morality and Religion),* and some arguments that remain very controversial, (such as over the relativity of time and space in *Duration and Simultaneity*). Nonetheless, there have been developments in both philosophy – in particular, poststructuralism – and in scientific endeavour – for example, some of the discoveries of contemporary neuroscience – where Bergson's ideas have, despite early criticism, proved far more accurate than his detractors'.

Contemporary evolutionary biology has been one of the principle sites for the development of the sciences of complexity, in the latter part of the 20th century. This development was greatly accelerated by the enormous advances in computing in the late 1980s and 1990s, and complexity science has spread to multiple sites and down multiple avenues, with the results disseminated from its multiple sources to equally multiple audiences during the 1990s and the first decade of the 21st century. In evolutionary biology computer models of molecular and biotic networks have given enormous insight into the workings of the natural world.

These advances prove to be a further reason to revisit the ideas of Bergson and see where, in like measure, his early critics may have been mistaken, and some of his primary arguments in fact much more cogent and powerful than at first thought. This book is not my attempt to suggest that 'Bergson was right all along,' or that 'Bergson saw it all first.' I shall not, either, spend much time discussing his critics, or those elements of his work that have not stood the test of time – in my eyes at least. It is clear that, within the confines and context of late 19th and early 20th century scientific achievement and European culture, there was much that Bergson cannot have seen and must, perhaps inevitably, have missed. Nor can one volume address the whole range of the new sciences of complexity – let alone in the context of the ideas of a French philosopher.

This book attempts, nonetheless, to suggest that there are elements of the philosophical perspective which Bergson brought to understanding the world – and specifically evolution – that chime exceedingly well with some of the core arguments of complexity theory found in its stronghold of environmental biology. Indeed, Bergson's ideas not only seem to underline and validate those scientific ideas with philosophical argument, but to expand upon them, suggesting to us a broader picture, with implications even wider than the sciences of complexity – already broad – have yet reached. Crucially, this perspective suggests an even further break from past approaches that the complexity sciences have yet to embrace; but which, when seen through the lens of Bergson's perspective, make cogent and compelling sense.

In short, the trajectory of the complexity sciences in post-Darwinian evolutionary biology is supported and clarified by some of Bergson's ideas, and – I argue in this book – we can gain a great deal of further insight from considering the two together. Ultimately, Bergson's concept of creative evolution (as described in his famous book of the same name), underpinned by his earlier works, may have both found scientific verification in contemporary complex evolutionary biology, and have further – fundamental – messages that complexity scientists should heed. In the end, I suggest a new understanding, which I have called *creative emergence*: it combines elements of Bergson's approach and that of the foundational ecological complexity theorists' into a new poststructuralist understanding of evolution, and of our place in the world.

Bergson viewed his work as a collaborative research project between science and philosophy, with the common aim of understanding life. His evolutionism, and his philosophy in general, he said, 'will only be built up by the collective and progressive effort of many thinkers, of many observers also, completing, correcting and improving one another.'[1] This book is my attempt to further this 'collective and progressive effort'.

This first chapter briefly reviews the life of the French philosopher, his legacy, and offers an abstract of the rest of the book. The second chapter details those of Bergson's core ideas of most relevance to the argument of this book. The third chapter reviews the rediscovery of Bergson at the foundation of poststructuralism, and some of the more recent scholarship around his ideas. The fourth chapter offers a poststructuralist genealogy of systems thinking as it has grown and changed since the 19th century, up until the advent of complexity. The fifth chapter, after addressing the question of time in classical and quantum physics, places the ideas of complexity theory and those of Bergson side by side, and posits a new approach which combines aspects of both. The sixth and final chapter offers a brief conclusion, with a consideration of our place in the world.

On Bergson's life

Henri-Louis Bergson was born on 18 October 1859 in Paris to a Polish Jew – a music teacher and composer – and a Jewess from the north of England, thanks to whom he was familiar with English from a young age.[2] Coincidentally, 1859 was the same year as the publication of Darwin's *Origin of Species*. Following a typical Jewish education he attended the Lycée Condorcet in Paris. While at the Lycée Bergson won prizes for his scientific work, and in 1877, aged 18, won a 'national prize in mathematics'[3] for the solution of a mathematical problem, which was published the following year in the *Nouvelles Annales de Mathématiques* – his first published work.[4]

At 19 he entered the famous École Normale Supérieure, where he read and became enamoured of the work of polymath and materialist Herbert Spencer. His education included the fields of literature, the natural sciences and philosophy, and 'the scholastic record he left behind him was one of uniform brilliance.'[5] Obtaining the degree of *Agrégation de philosophie* in 1881, he became a philosophy teacher at the Angers Lycée, in Anjou. In 1883 he moved to the Lycée Blaise-Pascal in Clermont-Ferraud, where he gave courses on the Presocratics, particularly Heraclitus. It was here that a major change occurred in his thinking, setting him against his earlier love of Spencer. In a letter of 9 May 1908 – to American pragmatist philosopher, William James, with whom he had a long and cordial association – Bergson provided a short paragraph on 'events worthy of note' in his life, of which he said there were none in his career, and only one, on the subjective side:

> I cannot but attribute great importance to the change which took place in my way of thinking during the two years which followed my leaving the École Normale, from 1881 to 1883.... It was the analysis of the notion of time, as it enters into mechanics and physics, which overturned my ideas. I saw, to my great astonishment, that scientific time does not *endure,* that it would involve no change in our scientific knowledge if the totality of the real were unfolded all at once, instantaneously, and that positive science consists essentially in the elimination of duration.[6]

As if to underline this shift, in 1884 he published a translation of Lucretius' poem, *De rerum natura* (On the Nature of Things), with his own commentary attached, already exploring what Gilles Deleuze would later describe as a counter history of philosophy.[7]

Returning to Paris in 1888, Bergson taught at College Rollin, and then at the Lycée Henri-Quatre, where he read Darwin and gave a course on his theories. His time in the provinces had not been wasted, however, and on his return to Paris he submitted his doctoral thesis, *Essai sur les données immédiates de la conscience,* which was published in 1889 (appearing in English as *Time and Free Will* in 1910). His Latin text, *Quid Aristoteles de loco senserit,* also published in 1889, was submitted alongside it.

In 1896 Bergson published *Matière et mémoire,* (which appeared in English as *Matter and Memory* in 1911) and in 1898 he was able to leave the world of lycées behind, and was appointed Maître de Conférence (roughly equivalent in the UK to the post of Reader, or to the US Associate Professor) at his old college, L'École Normale Supérieure, where barely a year later he was promoted to Professor.

In 1900 he was awarded the Chair of Greek and Latin Philosophy at the Collège de France, 'one of the highest academic posts in the nation'.[8] His essay *Introduction à la métaphysique* was published in the *Revue de Métaphysique et de Morale* in 1903 (appearing in English as *Introduction to Metaphysics* in 1913), and in 1904 he was appointed as Chair of Modern Philosophy, which post he kept until retirement.

His most famous work, *L'Evolution Créatrice*, was published in 1907 (appearing in English as *Creative Evolution* in 1911). This work was highly celebrated and made him a figure of international repute: 'People from all over the world came to Paris to hear him lecture, which he did with the same grace, felicity of phrase and originality of thought exhibited in his books. Yet neither the widespread adulation, nor the many honors he received had any effect on his modest, unassuming personality. Like all genuinely great men he possessed true humility of soul.'[9] So famous did he become that, between 1909 and 1911 'over two hundred articles about Bergson appeared in the British Press alone'[10] and he gave lectures in Oxford and Birmingham in 1911, and in New York in 1913. His popularity was riding so high among Catholic modernists that Catholic philosopher Jacques Maritain and others sought 'to put Bergson's works on the Catholic Index of prohibited material. They succeeded in 1914 – the same year in which Bergson was elected to the Académie Française.'[11]

Bergson enjoyed, then, until the outbreak of the First World War, the life of an extremely successful academic. But in 1916 his life took an unexpected twist: 'the French government entrusted him with a series of diplomatic missions, first to Spain, and then again decisively, to the United States, in 1917.'[12] This diplomatic voyage to the US was to try to convince President Woodrow Wilson to bring America into the war. 'To what extent his effort influenced events is difficult to assess,'[13] but the personal relationship Bergson formed with Woodrow Wilson continued during the drafting of the treaty of Versailles, in which Bergson 'continued to serve as a key intermediary between the French and American governments'.[14] Thereafter, his main 'post-war political contribution was his work with the Wilson administration to establish the League of Nations'.[15] The League was an intergovernmental organisation, founded in 1920 in the aftermath of the First World War, whose principal mission was to maintain world peace, and comprised almost

60 member countries by the mid 1930s. It foundered when the Axis powers left and the world descended once again into war, but was replaced in 1946 by the United Nations.

Capitalising upon his fame, in the years after the First World War Bergson gathered essays written between 1900 and 1914 into a new book, published in 1919, *L'Energie spirituelle: Essais et conferences,* which appeared in English as *Mind-Energy: Lectures and Essays* in 1920, the year Cambridge University awarded him the honorary degree of Doctor of Letters, and, in a gesture of good will, the Collège de France relieved him of his teaching duties. By 1921, however, ill health – the rheumatism which at the end of his life left him half paralysed – obliged him to retire.

His work with the League of Nations reached its pinnacle upon his retirement from academia, when he was appointed, in 1922, first President of the League's International Commission on Intellectual Cooperation (ICIC) – an attempt to show that intellectuals could work together at an international level, which included Einstein, Marie Curie, and many others. He held the post until 1925. However, this period also saw his very public disagreement with Einstein – on the nature of time – and the publication in 1922 of his least acclaimed work, *Durée et Simultanéité*, which appeared in English as *Duration and Simultaneity* in the same year.

Following his period with the League of Nations, capping a career that seemed already over, in 1927 he was awarded the Nobel Prize for literature, for *Creative Evolution* – 'in recognition of his rich and vitalizing ideas and the brilliant skill with which they have been presented',[16] and in 1928 he was elected a Foreign Honorary Member of the American Academy of Arts and Sciences. To crown it all, in 1930, aged 71, France awarded him its highest honour – the Grand-Croix de la Legion d'Honneur.

In 1932, fully 25 years after his masterpiece, *Creative Evolution,* he published his final work, *Les deux sources de la morale et de la religion* (which appeared in English as *The Two Sources of Morality and Religion* in 1935), and in 1934 a sequel collection of essays, *La Pensée et le mouvant: Essais et conferences,* including two never published before, (which appeared in English as *The Creative Mind* in 1946). His star, however, had already waned, and *Morality and Religion* only served to hasten his demise in the eyes of a newly polarised world.

In his final years, despite the Church's censure of his philosophical work, Bergson inclined to convert to Catholicism, saying in his will on 8 February 1937, 'My thinking has always brought me nearer to Catholicism, in which I saw the perfect complement to Judaism'[17] and that 'He would receive baptism in the Catholic Church were it not for the growth of anti-Semitism: he wants to remain among the persecuted.'[18] Indeed, after years as an invalid in retirement in Paris, in defiance of the Nazis after their conquest of France, Bergson refused the Vichy government's approaches, insisted on wearing a yellow star to show his solidarity with other French Jews, and queued for many hours – in the winter – to be registered.[19] Shortly thereafter, on 5 January 1941 – at the age of 81 – Bergson died of pneumonia.

As one commentator noted, 'The general public, and that relatively private clique known as the philosophical public, had long ago fallen into the habit of thinking of Bergson as dead. Only on the publication of the dramatic news of Bergson's decision to renounce all posts and honors rather than to accept exemption from the anti-Semitic laws of the Vichy government was the world reminded that he was alive'[20] – only, some weeks later, to learn the news of his death.

On Bergson's legacy

Bergson's fall from fame was, it seems, as swift as his rise. From the high point in the years following publication of *Creative Evolution*, his notoriety shifted from philosophy to his role as a political philosopher, engaged in the First World War and then in the League of Nations, and his public argument with Einstein. The poor reception of *Duration and Simultaneity*, and the general belief that the physicist had won the argument, was perhaps in keeping with the rise of classical physics as the primary discipline of modern society at the time, and a gift to Bertrand Russell and logical positivism's desire to reduce philosophy's scope and bring it into line with classical scientific principles. The voices of Bergson's critics rose and those of his supporters waned: eventually, no-one was talking about him at all.

Looking back from our vantage point in the 21st century, it is true that, not only was he perhaps unwise to take on the likes of Einstein, but there are moments in the latter part of Bergson's last book – *Two Sources of Morality and Religion,* published when he was 73 – when one can hear the voice of white male European superiority, born of and aggrandising a European Christian Gnosticism. Already made quite infirm by rheumatism in his late 60s,[21] and in the face of the rise of secularism,[22] caught between a nostalgia for his Jewish upbringing and a clearly genuine leaning toward the embrace of the Catholic Church, Bergson's final work seems at times breathtakingly insightful, at times simply (albeit touchingly) naïve – at least to 21st century minds.

But we should not forget that the intelligentsia of Europe, especially in Britain and France – whose empires, between them, owned and ran much of the world at the time (much to the chagrin of Nazi Germany) – remained even in the 1930s an intelligentsia of Christendom. It was, in fact, commonplace for talk of the Divine and of God to mix with the fruits of the natural sciences in lecture halls and conference rooms. Despite its official separation of Church and State in 1905, France remained one of the principal seats of European Catholicism in the early 20th century. Lloyd Morgan's emergentist evolutionism, with its Divine driving force, was welcomed at the Gifford Lectures in Edinburgh in the 1920s: albeit, his voice was not so welcome in the far more secular psychology departments of universities in the United States. Bergson, in the end – for all the prescient insights I will accord to him in this book – was a man of his time. When he died in 1941, 'the professional philosophers whose admiration had always been tinctured with critical reserve ... now found more to criticise and, what was perhaps more decisive, began to think in other terms about other problems.'[23]

Yet the philosophy he espoused in his younger years, and the political philosophy of his time with Woodrow Wilson and the League of Nations, still resonate. It is the primary task of this book to show how his philosophy meets so well the developments in scientific – and particularly evolutionary – thinking in the decades straddling the new millennium. But we will also see, in passing, how his ideas in the last decade of the 19th century accorded with the new quantum physics of the 1920s that made Einstein so uncomfortable. It should also not be forgotten that, after the Second World War, his work with the League of Nations flowered into one of the finest global organisations of all, the replacement for the ICIC: the United Nations Educational, Scientific and Cultural Organisation, commonly known simply as UNESCO.

That he was lumped in, by his logical positivist critics in the 1920s and 30s, with the vitalists (whom he expressly criticised in *Creative Evolution*) was a great misreading of his concept of the *élan vital*, and the debates around space-time that put him at loggerheads with Einstein are not a simple and straightforward case of Einstein being right and Bergson wrong: there are nuances of significant importance which still need to be teased out of this argument for a proper understanding of the nature of reality. His influence, in fact, can be traced through the ideas of several writers since: in particular with an impact upon the foundational ideas of poststructuralism in the 1960s, which I will explore in Chapter 3. Gilles Deleuze, especially, was a key rediscoverer of Bergson. His *Le Bergsonisme* in 1966 took the most challenging of Bergson's notions – his *intuition* and his argument with Einstein – and made of them a new understanding of multiplicities at the root of a new poststructuralist movement in French philosophy. Both Derrida and Foucault, in the same period, similarly adopted very Bergsonian positions on key questions, although neither really credited him.[24] As the 1970s and '80s unfolded scholars like Milič Čapek and Pete Gunter noted the confluence of Bergson's ideas with the implications of quantum physics; and by the 1990s Bergson's place in the history of philosophy was being disinterred from the archive to which he had been dispatched – dusted off by Kolakowski, and given a new lease of life by scholars such as Mullarkey, Guerlac, and Keith Ansell Pearson. Today, this volume joins a rash of new books about Bergson's ideas and continued relevance, across a range of disciplines and interests, from a host of new scholars in the field: one might almost suggest Bergson has become fashionable once more.

All this is in keeping, I believe, with Bergson's ideas: he was inclusive, humble enough to believe it would take the work of many to accomplish what he had but begun. After a short hiatus, then, this work, it would seem, is underway yet again, and I am glad to be one more voice among many. Ultimately, as Bergson himself asserted, it is when we bring all our voices together, that the best we can achieve will ensue.

From that same flawed *Two Sources of Morality and Religion,* in the first part, Bergson – the political philosopher – defined humanity in relation to a characteristic deconstruction of opposites: between the notion of societies, and of society; between that which is closed, and that which is open. Prefiguring, in some ways, elements of the later Foucauldian disciplinarity,[25] Bergson offered a description of the social as a system of obligation. A great believer in free choice – a faculty which consciousness grants us – Bergson nonetheless is all too aware that choice is soon overlaid by the necessary co-ordination required of social grouping. 'While his consciousness, delving downwards, reveals to him, the deeper he goes, an ever more original personality, incommensurable with the others and indeed undefinable in words, on the surface of life we are in continuous contact with other men whom we resemble, and united to them by a discipline which creates between them and us a relation of interdependence.'[26] This discipline and interdependence comprise a foundational moral obligation to one another that forms the glue of social grouping.

But these groupings are always, by definition, ultimately closed. Any individual grouping – be it family, clan, tribe, academic discipline, nation, or even a grouping of nations such Europe, or 'the West' – is 'to include at any moment a certain number of individuals, and exclude others'.[27] For Bergson, this is a 'natural' state, akin to the societies created by that other most social of Earth's creatures, the ant. Yet this is no simple biodeterminism,[28] for Bergson is clear on the essential point that human consciousness not only marks a fundamental distinction between us and the ant, but that consciousness itself is of a radically different nature to anything that science has yet approached – in part because it lies on the other side of a divide at the foundation of modern science itself. Having carved out his belief in human choice in *Time and Free Will*, in *The Two Sources of Morality and Religion* it is in the distinction between the closed and the open that Bergson finds choice at its most powerful, and its most human. 'Between the society in which we live and humanity in general there is ... the same contrast as between the closed and the open; the difference between the two objects is one of kind and not simply one of degree.'[29] The spirit of the League of Nations, still alive in the United Nations, is imbued with just this very openness – an expansive inclusivity very different from the closed inclusivity of nationalism.

Bergson's legacy, in sum – in both his philosophical critique of reductionist positive science, and his internationalist political philosophy – offers very contemporary insights into the complexity of evolutionary and climate science and the collaborative approach needed to address the problems too blinkered a view of the world has brought to us.

On creative emergence

Perhaps Bergson's primary task – the idea that drove him – was to promote this very openness of spirit. He never claimed to have created, or be putting forward, a coherent – for which read 'closed' – philosophical system. His were a set of ideas, a methodology for moving forward, and a spirit of inclusivity and inquiry, that desired the best from wherever it might arise. He set himself against closed and rigid systems of thought that required of all answers that they first be set in language that might, in the end, obviate their point.

Despite his famous promotion of *intuition* and his critique of scientism, Bergson was also the boy who won a national prize in mathematics, the student enamoured of Spencer's clockwork universe, and his books were founded on an extraordinary breadth of scientific reading and understanding: both of the burgeoning neuroscience of his day, for *Matter and Memory,* and of the whole range of contemporary understandings of evolutionary biology, for *Creative Evolution.* His principle argument, in *Duration and Simultaneity,* was that philosophy did – and should – retain a place in the intellectual pursuits of society, and that physics should not try to overstep its proper area of concern; that philosophy, in short, had something to say about time that physics could not, and should not try to. His work with the League of Nations, of course, is a shining example of this openness of spirit, this expansive inclusivity. In all his work, Bergson repeatedly offers to scientific thinking the possibility that philosophy – if it is not kept at heel under science's supervision and granted only meagre scope for discussion – can and should be able to provide far greater insights: not at the cost of science, but for its enrichment. This was not – as with the logical positivists – an attempt to grant philosophy a place by absorbing scientific principles into itself, making itself a handmaiden to science; this was an attempt to place philosophy alongside science in its own right – as something which could see further and deeper if given free rein, and spawn ideas that, given the necessary empirical proving, could be of great use to science. He never suggested that the fruits of *intuition* should not be tested. If not empirically proven such intuition is, after all, mere fancy. But without the freedom to *intuit,* and the method by which to undertake such exploration, how can great ideas be found?

Using his unique and incisive *intuition*, Henri-Louis Bergson brought to us, in the decades straddling the turn of the 20th century, not just this key idea of philosophical *intuition*, and its place alongside science, but an idea that could truly be called 'great' – an idea so fundamental as to mark a moment in the development of philosophy and of science that resonates across centuries: the notion of the *durée réelle,* of real time. A scholar of Greek philosophy, it is indeed to the Presocratic Eleatics that Bergson ascribes the principal failing by which classical scientific endeavour had come to efface time from its worldview. For Bergson, the 'time' of science, since the Greeks, is simply a collection of 'instants' laid out side by side in space: not, in fact, anything that *endures* at all. Yet real time, the *durée réelle* of which he speaks, is something that each and every one of us knows immediately, because we *live* it. The time of classical science, for Bergson, purports to determine all existence from beginning to end in a fixed, mechanical, inescapable grip. Yet lived time, as any of us might surmise – for all that the possible is constrained – contains nonetheless many potential futures, and it is often conscious choice which determines which way things will unfold.

The implications of this primary insight – which he first put forward in his doctoral thesis, and comes down to us in his book *Time and Free Will* – he explored in his next two books. First, in his *Matter and Memory*, he addressed the nature of the mind–body problem, which Descartes had bequeathed to both philosophy and science by so completely dividing one from the other. Then, in *Creative Evolution*, Bergson considered the question of how we come to be here – and what indeed we are.

His solutions for each of these most profound questions are at all times temporal – always turning toward mobility, movement, and change, in keeping with the primary insight of the *durée réelle*. For Bergson, in many senses, at bottom, mind *is* time; thus, when reformulating the primary Cartesian divide between mind and matter, Bergson at every step of his arguments shows us a new monistic understanding of the old duality, infusing matter with mind because it *endures*. In this reading, our perception of 'objective' reality is an activity – a flow that incorporates all objects, to the extent that objects themselves must be regarded as activities, rather than as fixities. Our perception of these objects is conditioned by their usefulness to us: be they food or something not to bump into. Memory, in this reading, becomes key both to the flow and mobility of reality and to the key role of free will: the movement from past to present to future is pregnant with possibilities and it is choice, based upon memory of the past and imagination of the possible future, which settles on one rather than another.

Bergson's universe is thus infused with consciousness – to varying degrees – because it *endures*. This consciousness, moreover, beyond the simple inert matter of existence, acts *upon* that inert matter to generate life. For Bergson, life is understood as the gathering, ordering principle that sets itself in opposition to the entropy of the inert. Life, bursting forth explosively wherever it can, always seeks ever greater and more diverse forms. Contrary to all the various evolutionary ideas current in the brand new ecological science of his day, for Bergson life is driven by another of his famous *intuitions*, the *élan vital*: a principle of ordering and a direction of flow, not some magic substance or divine essence that somehow distinguishes the living from the inert. Consciousness, acting upon inert matter through life, ultimately seeks out its mirror, and includes, at its pinnacle, self-aware and social consciousness, in the form of humankind. We are not nature's perfection – nor indeed the best possible outcome, let alone inevitable. It is, no doubt, possible that there are many such self-aware and social consciousnesses on planets far away – perhaps even where there is neither carbon nor water – and the inert matter which consciousness has used to break through into life there includes constituents which are very different from our own. But we represent, for Bergson, that which life is ultimately for, what existence is finally about, and have a duty to make the best of it: together, and not in closed silos keeping each other out. These core ideas are fleshed out in Chapter 2.

In Chapter 3, I turn my attention to the legacy of Bergson's ideas. The irruption of the notion of time into philosophical thought, and its challenge to classical science, long after Bergson's star had waned and disappeared, was rediscovered in the 1960s at the birth of poststructuralist thought, and surfaced in contextualism and multiplicities – the difference and anti-rationalism of authors such as Gilles Deleuze, Jacques Derrida, and Michel Foucault. Ideas on language from Bergson's contemporary, Ferdinand de Saussure, and on history from their predecessor, Friedrich Nietzsche, combined with Bergson's insights into time and multiplicity to produce some of the most radical philosophy – and philosophers – of the 20th century. These writers understood how presiding scientific consensus – such as that which Bergson set himself up against – was in fact little different from any other presiding consensus at any other particular historical juncture one might wish to choose: contingent, dependent upon a range of personalities and embedded practices, and riddled with relations of power. Truth, in other words, for these philosophers, was relative.

Such insight, indeed, is telling when one looks at the history of systems thinking, as I do in Chapter 4. For many decades after Bergson, and the quantum mechanics that chimed so well with his primary insight into the nature of time, the mechanistic world of classical science continued – bolstered by the interests of economic and political elites and through the upheavals of war – to hold sway over both philosophy and scientific endeavour. Right up until the 1970s ecologists believed algebraic equations, built upon classical dynamics, told them the truth about animal populations: even when the empirical facts, gathered in the field, completely contradicted their formulae.

But with the advent of one of the finest tools mathematics, physics and engineering have ever brought us – the computer – we have been able to model and to understand systems better than ever before; and since the 1970s, systems thinking and ecology have undergone radical change. Here, finally, with the same iconoclasm as poststructuralism, decentring the 'units of selection' of Darwinian evolutionism, and setting natural selection into a new structural context – where chance, tendency, and a complete lack of internal equilibrium place life teetering on the edge of chaos, a new breed of evolutionary biologists, armed with powerful computers and a new kind of dynamics – that of networks – is bringing us a radically different kind of evolutionary theory.

Strikingly, as I shall lay out in Chapter 5, this new evolutionism, informed by complexity theory, turns out to be very much in keeping with Bergson's own evolutionism: the principle of self-organisation in living systems the very *élan vital* of which Bergson wrote a century ago, in his *Creative Evolution*.

Finally, in the last chapter I outline the possibilities of a new approach to understanding evolution: *creative emergence*. I do so in the hope that bringing together many more voices than my own may open up possibilities for a greater understanding of our place in the world – and of the nature of evolution, of time, and of our role in it. I do this, indeed, at a time when, if we do not act in concert, and quickly, it may be that the actions we have already taken, in the silos of our nations and corporations, might render this world far less habitable than we have – as a species – been used to.

Notes

1. Bergson, H (1944[1907]) *Creative Evolution*. Trans. by Arthur Mitchell, with a Foreword by Irwin Edman. New York: Random House Modern Library p. xxiv
2. Kolakowski, L (1985) *Bergson* South Bend, IN: St Augustine's Press. p. vii
3. Papanicolaou, A. and Gunter, P (1987) (eds) *Bergson and Modern Thought* Chur: Harwood Academic Publishers p. xvi
4. *Nouvelles annales de mathématiques: journal des candidats aux écoles spéciales, à la licence et à l'agrégation* Paris, Carilian-Gôeury' et Vor Dalmont [etc] 1842–1927 https://catalyst.library.jhu.edu/catalog/bib_416912
5. Thomas Goudge (1949) Introduction to 1912 translation of *Introduction to Metaphysics* Trans. T.E.Hulme, Cambridge: Hackett Publishing Company p. 9
6. Perry, R.B. (1935) *The Thought and Character of William James*. Boston: Little, Brown 2:622–623, https://archive.org/details/thoughtandcharac032117mbp
7. Deleuze, G and Parnet, C (1987) *Dialogues* (Trans. Hugh Tomlinson and Barbara Habberjam) London: The Athlone Press pp. 14–15
8. Thomas Goudge (1949) Introduction to 1912 translation of *Introduction to Metaphysics* Trans. T.E.Hulme, Cambridge: Hackett Publishing Company p. 9
9. ibid. p. 10
10. Burwick, F. D., Paul eds. (1992). *The crisis in modernism: Bergson and the Vitalist Controversy*. Cambridge: Cambridge University Press p. 3
11. ibid. p. 2
12. Lefebvre, A and White, M (2012) *Bergson, Politics and Religion* Durham: Duke University Press p. 2
13. Kolakowski, L (1985) *Bergson* South Bend, IN: St Augustine's Press P. viii
14. Lefebvre, A and White, M (2012) *Bergson, Politics and Religion* Durham: Duke University Press p. 3
15. ibid. p. 3
16. http://www.nobelprize.org/nobel_prizes/literature/laureates/1927/
17. Bergson's will quoted by Zolli, Eugenio (2008[1954]). *Before the Dawn*. San Francisco: Ignatius Press. p. 89

18. Kolakowski, L (1985) *Bergson* South Bend, IN: St Augustine's Press p. viii
19. ibid. p. ix
20. *CE* p. 9
21. Bergson was so unwell in 1927 that he was unable to travel to Stockholm to collect his Nobel Prize for Literature, and sent a 'thank you' speech instead.
22. See Taylor, C (2007) *A Secular Age* Cambridge: Harvard University Press
23. *CE* p. 11
24. Jacques Derrida cites Bergson, from *Time and Free Will,* on the conflation of temporality and space, in his *Writing and Difference* (1967[1978]) London: Routledge p29 when discussing the 'volume' of writing, and also in his *Of Grammatology* (1967[1976]) Baltimore: Johns Hopkins University Press, where he merely states, in passing, when discussing Levi-Strauss' harsh criticisms of philosophers such as Bergson: 'of which I shall say nothing here except to note that only their ghosts, which sometimes haunt school manuals, selected extracts, or popular opinion, are evoked here' (p. 117). Taken with his reference elsewhere to addressing metaphors – that he must do 'as Bergson wished' (p. 67) – perhaps we might suggest that Derrida did indeed, albeit very quietly, acknowledge a debt to Bergson. But, beyond this Derrida seems largely focused on thinking 'in other terms about other problems'.

    Foucault, to my knowledge, never references Bergson until what is perhaps one of his very last writings, *Life, Experience and Science,* (1985) *Revue de metaphysique et de morale* 90:1 pp. 5–14, in which he speaks of a dividing line through French thought that 'separates a philosophy of experience, of meaning, of the subject, and a philosophy of knowledge, of rationality, and of the concept. On one side, a filiation which is that of Jean-Paul Sartre and Maurice Merleau-Ponty; and then another, which is that of Jean Cavailles, Gaston Bachelard, Alexandre Koyre, and Canguilhem. Doubtless this cleavage comes from afar, and one could trace it back through the nineteenth century: Henri Bergson and Henri Poincare.' p. 6. Foucault only recognises duality where it is a presage to a more real plurality, and would never acknowledge any debt to Bergson. Nonetheless, it is fairly clear that Foucault himself – judging by his critique – was not on the side of the dividing line opposed to Bergson!
25. Foucault's primary early contribution was famously his notion of society as modelled upon Bentham's panopticon – a circular prison where a central control tower can view each prisoner, but the prisoners cannot see one another. The surveillance provides the social control. This model for society he termed disciplinarity.
26. *TSMR* p. 14
27. *TSMR* p. 30
28. See, for example, Wilson, E.O. (2012) *The Social Conquest of Earth* London: Liveright. Wilson's assumptions are that science will solve the riddle of consciousness in a generation (p9) and that our large size and relative lack of mobility are the primary causes of our development of long memory and distant predictive imagination, which have made our eusociality radically different from that of the ants. Like many scientists, he dismisses philosophy as having anything to say on the matter.
29. *TSMR* p. 32

2
Bergson's Core Ideas

On method

Bergson's core ideas concern intuition, *durée réelle*, memory and perception, and the *élan vital*. In this volume I will mostly be using the terms he used, in French, for *durée réelle* and *élan vital,* because the English translations – commonly 'duration' or 'real time' for *durée réelle*, and either 'vital impetus' or 'life drive' (among others) for *élan vital,* are inadequate.[1] For simplicity I shall attempt to deal with each of them in turn; but as the reader will grasp, they are very closely interrelated, interpenetrating, even built upon each other. The concept of the *élan vital* will become the most important, to the concerns of this book, as it unfolds, but to understand this concept fully the other concepts must be explored first.

Bergson's core ideas reflect, and his presentation of them includes some primary and very characteristic approaches, or methods, which it will be helpful to lay out prior to considering the ideas themselves.

1. *Monistic Dualism: two sides of one coin*. Bergson often presents his readers with pairs of opposites that he assures us are never found alone, purely one or purely the other; but always, in reality, in combination. Yet for the purposes of his argument he asks us to imagine each half of these pairs in its pure state, in order better to understand them, and their combination. For example, he asks us to do this with space and time.
2. *'Deconstruction'*[2] is another method with which Bergson addresses pairs of ideas – taking the two opposite sides of a debate and showing how they in fact both share a common misunderstanding at the root of their division. For example, he does this with idealism and realism.

3. *The nature of difference.* Many of these pairs, Bergson enjoins us to understand, differ in *kind*, rather than in *degree* – another of his favourite distinctions. For example, this is his distinction between quality and quantity.
4. *Mobility, multiplicity and continuity*. More a perspective, perhaps, than strictly a method, Bergson frequently enjoins us to understand what he is describing as multiple, continuous, and on the move, rather than as singular or fixed. Multiplicities appear in many of his arguments, and mobility is often used to counter assumptions about 'things'.

Of all Bergson's core ideas, the *durée réelle* may perhaps be regarded as his primary insight: an understanding of the nature of time that formed the core of his PhD thesis, later published as his first major book, *Time and Free Will*. His understanding of intuition depends on this perspective on the nature of time. This faculty of intuition – as it is envisioned by Bergson – is the means, the *method* of his philosophy. It is in a universe that can only be seen through the lens of this understanding of time, apprehended by this philosophical intuition, that Bergson's understanding of human perception, and of the nature of memory, are situated. Finally, the movement, the indivisibility, the impetus that drives this time forward, Bergson calls the *élan vital,* a creative impulse so creative it belies any teleology: any plan such an impulse could be said to follow would imply that such a plan's end point somehow pre-existed its arrival at such a predetermined goal, rendering its creativity merely one of implementation. Bergson's *élan vital,* by contrast, has no such plan: his is a universe that is making itself up as it goes along. Far from being some kind of substance, essence, or mysterious or divine force – as suggested by vitalists such as Stahl, Driesch[3] and others – the *élan vital* is a property of matter understood through the lens of Bergson's understanding of time: matter that is not, is never, fixed, but is constantly, ineluctably on the move.

Yet for all the seeming coherence of these core ideas, as described above, Bergson is clear that he in no way presents to us a philosophical *system*. He tells us that 'a philosophy of this kind will not be made in a day'.[4] Indeed, he envisages his work as merely the beginning of a wider project: 'Unlike the philosophical systems properly so called, each of which was the individual work of a man of genius and sprang up as a whole, to be taken or left, it will only be built up by the collective and progressive effort of many thinkers, of many observers also, completing, correcting and improving one another.'[5] Even then, however, positing a truly intuitive metaphysics that followed his method of *intuition* *philosophique*, Bergson is keen to point out that, 'It would not begin by defining or describing the systematic unity of the world: who knows if the world is actually one? Experience alone can say, and unity, if it exists, will appear at the end of the search as a result; it is impossible to posit it at the start as a principle.'[6] So, as one of the earliest commentators on his work, H. Wildon Carr, pronounced, in 1919, 'the philosophy of Bergson is not a system. It is not an account of the ultimate nature of the universe, claiming to be a complete representation in knowledge of all reality.' Ultimately, 'one of its most important conclusions is that the universe is not a completed system of reality, of which it is only our knowledge that is imperfect, but that the universe is itself becoming.'[7]

Given the interrelated nature of these core ideas, then, and their implied incompleteness, I will attempt to describe each in turn, yet inevitably enjoin the reader to try to grasp them all at once – in the manner, perhaps, of the *intuition philosophique,* with which I shall begin.

On the *intuition philosophique*

The distinction in Bergson's thought between the rational mind of science and what he termed the *intuition philosophique* of consciousness has perhaps been one of the most contentious of his insights. It has led some to assume – wrongly – that Bergson was a mystical philosopher, anti-scientific, wedded to a wrong-headed idealism or a belief in mystical intuitive powers. He was none of these things. In particular, Bergson very specifically rose above the realism/idealism debate, subjecting it to his characteristic philosophical method of deconstruction – taking the two opposite sides of a debate and showing how they, in fact, both share a common misunderstanding at the root of their division. He was also very particular about the way in which he used the word 'intuition'.

I will here begin with a few remarks on Bergson's use of, and relationship with the science of his day. It will become clear that his philosophical distinctions both accept the efficacy and veracity of the scientific method, at the same time as presenting us with an understanding of the universe about which that method can, by definition, only grant us partial knowledge. As Adamson put it, (rather succinctly, in my view):

> the epistemological foundations of science, as much as the ontological grounds of the object of any scientific point of view, draw a clearly definable line between that which science is capable of describing and that which philosophy has the potential to express. This distinction is drawn by the difference between the discrete and

> the continuous. Science is, unavoidably, constrained within and by, the ontological limitations of the discrete, for the simple reason that it is the necessary condition of both information and objectivity. The objective can only be determined when, as Bergson puts it, we take a 'snapshot' of duration.[8]

Following some further remarks on this distinction, I shall proceed with a description of Bergson's *intuition philosophique.* I shall return to this in some detail in the next chapter, when considering Gilles Deleuze's essay on Bergson, *Le Bergsonisme,* but will restrict myself, in the first instance, to Bergson's own writings on the subject.

On rationality

Bergson had no issue with scientific advance; and, indeed, used the science of his day liberally throughout his work. In *Time and Free Will,* for example, discussing the nature of attention, focus, and the experience of muscular effort, Bergson refers to Helmhotz's work on the physiology of the eye, Ribot's work on the mechanics of facial expressions, and Darwin's description of the symptoms of rage.[9] In *Matter and Memory,* Bergson makes reference to the ongoing work in the journals, *Brain,* the *British Medical Journal, Revue de Medicin, Berliner Klinische Wochenschrift,* and books by Freud, Kussmaul, Bernard, and many other scientists of his day, concerning the then current understanding of aphasia (problems with comprehension and expression of language caused by brain dysfunction) and other neuroscientific concerns.[10] In his deconstruction of the realism/idealism debate, in *Matter and Memory,* Bergson is explicit in supporting not just the 'success' of science, but the importance of scientific knowledge, which he uses in his arguments.[11] The list of biological and environmental journals and treatises he uses in *Creative Evolution* is extensive; as we shall see in Chapter 5. In *Creative Evolution,* when refusing to take sides in the debate around the heritability of acquired characteristics, he is emphatic that 'Nowhere is it clearer that philosophers cannot today content themselves with vague generalities, but must follow the scientists in experimental detail and discuss the results with them.'[12]

Nonetheless, science presents us with a great number of theories, each of which, in its own partial view of the totality, supported by its relevant facts, presents us with but a partial understanding. This, Bergson asserts, is where philosophy steps in. 'The reality of which each of these theories takes a partial view must transcend them all. And this reality is the special object of philosophy, which is not constrained to scientific precision because it contemplates no practical application.'[13] Arising from this overview, and no doubt the root of the contentiousness of his philosophy, and perhaps the cause of his relegation, after his heyday, 'to the status of a footnote in histories of philosophy, making a brief appearance in studies of "vitalism" or "irrationalism"',[14] was his critique of rationalism and scientific realism. It is perhaps instructive to briefly define these terms, in the sense that I shall be using them in this discussion.

Rationalism is a view that regards our faculties of reason – our intellect – as of the highest order, over and above any emotive or sensory or other faculties, and that through reason – and reason alone – we can come to know all truth, without necessarily, indeed, recourse to any evidence. It is in some senses the opposite of Empiricism, the famously British approach that emphasises the importance of sensory experience in the development of knowledge: a key element in the experimental scientific method; the empirical scientist observes tangible actualities. Realism, in philosophy, suggests that reality is ontologically independent of our perceptions and whatever we come up with in our thinking to explain the world, and that it exists entirely independent of the mind: our concepts about reality are always approximations and improve as we gain new insights. Scientific Realism is a view that the world as described by science is the real world, and that even what science cannot observe must in fact be real because science describes it, rationally. These positions are clearly both closely related and at the same time, in part, contradictory. The rationalist is happy to theorise without doing any empirical science, and the scientific realist a believer in the metaphysical power of rationality to describe a reality that cannot be observed.

But even at the time Bergson was writing, the position known today as 'instrumentalism' was being introduced, by Duhem, to the physics community, and has 'in the meantime become commonplace'[15] amongst physicists. Instrumentalism, in a nutshell, acknowledges that physics cannot grant a true vision of things-in-themselves (particularly not with respect to 'unobservables', such as subatomic particles) any more than religious myth and the philosophical systems of the past were able to. Duhem instead asserted that, 'A physical theory is not an explanation. It is a system of mathematical propositions, derived from a small number of principles, whose purpose is to represent a set of experimental laws as amply, as completely, and as exactly as possible.'[16]

For Bergson, reason and logic alone are not sufficient to gain a proper understanding of the universe: some actual scientific research is essential. In this sense his approach is more empirical than rationalist. More significantly, however, there are for him aspects of the universe that are simply not susceptible to the scientific method of abstraction, experiment and analysis, and where indeed the intellect, rather than offering us clarity, obfuscates our understanding, presenting us with an image of the stable and predictable where in truth the radically unknown is in the process of creation. His challenge to the scientific realist and the rationalist is thus not to science itself – or indeed to rationality – but to the self-referentiality of reason, and what, thereby, it misses. A rational critique of reason, for Bergson, is an empirical one that acknowledges Descartes' distinction between body and mind (for Bergson, a difference in *kind* rather than *degree*) whilst challenging Descartes' conclusion that we can thereby consider the one in the absence of the other. For Bergson, they are two sides of the same coin, and by reducing the world only to that which we can understand through the mechanistic physics of empirical science we miss the other half of the universe – that half that does the experiencing, examining, and understanding, and – even more so – what else that half could grasp if we but let it.

His challenge, ultimately, is that the way science goes about its work excludes too much of the universe for it to claim to be able to understand it in total. Firstly, science makes incorrect assumptions about that which – with its rational methods that capture only fixities – it fails to grasp, *viz* the mobility of the universe. Secondly, because it privileges only the faculty of reason – to the exclusion of all else – science cannot know the nature, and place within the universe, of consciousness, for which reason is but one of many faculties.

The rationalist, the realist, the scientific realist – even the instrumentalist, all make the same fundamental distinction: between what is regarded as an interior, mental/emotional subjective part of the universe (inside us) and an exterior, real/material objective part of the universe outside of us: for them the former (interior) reasons about, experiments upon, and describes the latter (exterior).

Yet – as Bergson so lucidly points out – while the science of biology is quite clear about the objective reality of our own bodies, this continues right up to, and includes, the chemical workings of the brain, where our thoughts and emotions are supposed to take place.[17] In Bergson's time this neuroscience was in its infancy; but he could see even then that, philosophically, it would always be examining, through the scientific method, the objective reality of the brain: it would never gain access to the mind. The 'inner' against which all the 'outer' are opposed, in these ontological views of the universe, seems not to have any place in it, beyond being where 'we' reside, and undertake our thinking and our feeling – whether or not we favour one over the other. Even the electrical activity of synapses in the brain is regarded as an 'objective' reality susceptible to our 'subjective' experience – an 'outer' to our 'inner', leaving the location of that 'inner' an unanswered impossibility, an experienced reality with no place in the real. It is here, at the junction of science and the realm of consciousness – and by extension, the realm of life – where Bergson's philosophical method attempts a new synthesis between science and metaphysics: a synthesis that can ground philosophy in the real, and make philosophy relevant to science, in ways barely attempted since Descartes rent them asunder.

On intuition

How he addresses this conundrum – the perennial mind/body problem in the philosophy of mind – with his theory of 'images' and his monist dualism, I shall come to presently, when considering Bergson's core ideas on memory and perception, and in the next chapter, when considering how Bergson's ideas have informed more contemporary understandings of the subject/object distinction. For the moment, I wish to introduce the alternative he proposes to the rationalist approach, the other faculty of consciousness or other 'aspect of self'[18] he speaks of, which is, above and beyond his critique of rationalism, what most upsets the scientific realist: *intuition philosophique*.

Intuition, in common understanding, is the ability to understand something without the need for conscious reasoning. The implication that one can 'know' anything somehow by instinct, or gut feeling, or some kind of mysterious inner perception, is clearly anathema for the rationalist, for whom only the intellectual faculty of reason can bring knowledge. For Bergson, indeed, 'intuition' is a word he chose with some hesitation: 'Because a Schelling, a Schopenhauer and others have already called upon intuition, because they have more or less set up intuition in opposition to intelligence, one might think that I was using the same method.'[19] Clearly, however, he is not. On the contrary, Bergson's understanding of the nature of his *intuition philosophique* is very different. It is more what one might call 'apprehension,' even a 'gestalt' presence in the moment and in the world, that in fact implies or presupposes one of Bergson's most famous core ideas: the *durée réelle*. In this sense, for Bergson, intuition is 'neither a feeling, an inspiration, nor a disorderly sympathy, but a fully developed method'[20] or philosophical approach. Indeed, as I have already suggested, the methodological thread of intuition ties together the relationships between the core ideas of *durée réelle*, memory and perception, and *élan vital*. In this sense, for Bergson, his *intuition philosophique* is indeed the 'true empiricism'[21], focused upon immediate sensory experience of the real.

This strong appeal to an empiricist intuition earned Bergson many critics. The accusation of 'irrationalism' levelled at Bergson, it must be said, is largely because of this aspect of his philosophy, rather than any other. He proposed it most identifiably in his 1903 essay *An Introduction to Metaphysics*[22] and also in his 1911 lecture *Philosophical Intuition*.[23] He characterised it specifically as the best approach to precisely the absolute kind of knowledge Kant had firmly regarded as impossible[24]. Bergson's argument – contra Kant – concerning this absolute knowledge, is a simple one, using one of his characteristic pairs of opposites, which differ in *kind* rather than in *degree*. There are two ways to know a thing, he suggests: either *relatively*, from a range of perspectives in fragments, or *absolutely*, by going directly into it, and grasping it whole. Analysis gives a relative knowledge; an empiricist intuition gives an absolute knowledge. Using language, relative knowledge calls upon symbols and generalised ideas and fragments of knowledge and tries to weave a patchwork description around a thing that inevitably distorts it.[25] The object's uniqueness is ignored. Absolute knowledge, by contrast, dispenses with symbols, inverting habitual modes of thought, and is apprehended through the intuitive method, by which what is unique and ineffable about the object can be grasped. Direct, empiricist, experience is thus the key to absolute knowledge; representation, symbol and interpretation the character of relative knowledge.

These ideas are a key challenge to Kantian philosophy, wherein the very idea that such absolute knowledge is possible was challenged and disregarded. But, as Bergson points out, from the perspective of his *intuition philosophique* and its empiricist grasp of objects in the now, 'in order to reach intuition it is not necessary to transport ourselves outside the domain of the senses and of consciousness. Kant's error was to believe that it was.'[26] The very transcendental and metaphysical view of intuition that Kant and others rejected, Bergson also rejects. Yet this does not mean that intuition does not exist, in a much more present, sensuous and conscious form; and Kant himself made very strong arguments that were intuition to exist, it would indeed be the way in which to grasp absolute knowledge of things. As Bergson asserts, 'One of the most profound and important ideas in the *Critique of Pure Reason* is this: if metaphysics is possible, it is through a vision and not through a dialectic.'[27] Yet this 'intellectual' intuition, as Kant termed it, he deemed impossible, because he conflated it with the metaphysical intuition favoured by the post-Eleatic Greeks and the history of philosophy thereafter: an intuition of Schelling or Schopenhauer, which they all understood as 'a faculty of knowing which would differ radically from consciousness as well as from the senses.'[28] For Bergson, true intuition is the opposite: it is to 'grasp change and duration in their original mobility' with the faculties of our senses and consciousness undimmed by the habits of our intellect.[29]

In his celebrated lectures on *The Perception of Change* to the University of Oxford in 1911 (published in extended form in 1946) Bergson indeed suggests that metaphysics 'as a matter of fact, was born of the arguments of Zeno of Elea on the subject of change and movement',[30] and the ancients' misapprehension of the nature of mobility. We shall come to this shortly, for in it lies a key to Bergson's ultimate philosophical position, the insight he first expressed in his doctoral thesis, from his study of the Greeks.

The first three key propositions Bergson makes in his *Introduction to Metaphysics* are important to restate here, as they capture well some of the fundamental elements of what he means by the *intuition philosophique*:

1. *There is an external reality which is given immediately to our mind.* Common sense is right on this point against the idealism and realism of the philosophers.
2. This reality is mobility. There do not exist *things* made, but only things in the making, not *states* that remain fixed, but only states in process of change. Rest is never anything but apparent, or rather, relative. The consciousness that we have of our own person in its continual flowing, introduces us to the interior of a reality on whose model we must imagine the others. *All reality is, therefore, tendency, if we agree to call tendency a nascent change of direction.*
3. Our mind, which seeks solid bases of operation has as its principal function, in the ordinary course of life, to imagine *states* and *things*. Now and then it takes quasi-instantaneous views of the undivided mobility of the real. It thus obtains *sensations* and *ideas*. By that means it substitutes for the continuous the discontinuous, for mobility stability, for the tendency in process of change it substitutes fixed points, which mark a direction of change and tendency. This substitution is necessary to common sense, to language, to practical life, and even – to a certain extent, which we shall try to determine – to positive science.[31]

Thus, the relative knowledge of the intellect, the *Pure Reason* which Kant critiques, the world of symbols, presents to us *states* and *things* that are in truth snapshot moments of an undivided and unceasing mobility, which we can only apprehend with all our senses and our consciousness heightened and alert. We might summarise, then, in Bergson's own words, that intuition, 'signifies first of all consciousness, but immediate consciousness, ... vision which is scarcely distinguishable from the object seen, and knowledge which is contact and even coincidence.'[32]

In this sense then, Bergson is not just an empiricist rather than a rationalist, he is also more of a realist than the realists and the scientific realists. Bergson's realism acknowledges that our perceptions – because they are biological – of reality, are far from being ontologically independent of reality, but in fact far better able to grasp and understand reality than whatever we can come up with in our thinking to explain the world. Reality in this sense remains independent of the mind; and our intellectual concepts about reality continue to be approximations which improve as we gain new insights. But – as we shall see below when considering perception and memory in more detail – because our perceptions are understood to coincide with, as a part of that empirical reality which our mind grasps, the 'independence' of mind and reality is a quality of time: or, more specifically, of duration, of the *durée réelle*.

On *Durée Réelle*

In *Time and Free Will*, published in 1889, Bergson sets out his primary idea concerning the nature of reality: an understanding of time that goes contrary to that of both scientific endeavour and most philosophical systems. He argues that the idea of a homogeneous and measurable time is an artificial concept, formed by the intrusion of the idea of space into the realm of duration. As with many of his ideas, he is at pains to reassure us that, of course, the opposites that he describes are never found alone, purely one or purely the other, but always, in reality, in combination. This is as true of space and duration as it is of other pairs he describes here, such as quality and quantity, affective and representative sensations, and so on. Yet, for the purposes of his argument, he asks us to imagine each half of these pairs in its pure state, in order better to understand it, and in order then, once considering their combination, to better understand how they differ in *kind*, rather than in *degree* – another of his favourite distinctions. Once these distinctions are understood, we can then follow his argument: that many philosophical problems are based upon misconceptions, upon an attempt to understand one half of one of these pairs in the terms of the other.

Duration – the *durée réelle* – is the key insight enabling all these distinctions and re-imaginings, and the 'solutions' to all the various philosophical problems whose misconceptions Bergson reveals. In some cases, it is difficult to grasp, because, as Bergson would argue, of the many centuries of intellectual thought that have built up describing things in the wrong way. In other cases, it remains common sense, something that we intuitively grasp without recourse to intellect. He reminds the reader of 'the specific feeling of duration which our consciousness has when it does away with convention and habit and gets back to its natural attitude,' and enjoins us to remember this understanding of the *durée réelle* as he shows us how 'at the root of most errors in philosophy' one can find precisely this 'confusion between ... concrete duration and the abstract time which mathematics, physics, and even language and common sense, substitute for it.'[33] This is the core idea of the *durée réelle:* a conception of a continuous reality that is tempero-spatial, in direct contrast to the discontinuous, scientific conception of the spatio-temporal discrete moment that science casts as the real.

In *Time and Free Will*, Bergson outlines his argument in stages, first with an essay on the intensity of conscious states, and then regarding the idea of duration in the context of our conceptions of number. His argument for duration rests upon an understanding of the difference between quality and quantity, and then of how quantity implies space, and quality implies duration. He suggests that our conscious states are basically qualitative, and cannot be adequately described or measured in terms of quantities, and that quantities are understood only spatially, and qualities only durationally.

On the intensity of conscious states

Bergson approaches his argument around the nature of time first through an essay on the difference between quantity and quality in the context of the intensity of conscious states. His argument is that it is a fallacy to imagine we can give descriptions proper to external (extensive) reality to our internal (intensive) conscious states. Whilst he acknowledges that the majority of sensations 'are manifestly connected with their external cause,' he asserts, nonetheless, that conscious states cannot be described in the same way. To say a feeling is more or less intense, to imply one could increase or decrease the intensity of such a conscious state, is, for Bergson, to confuse quantitative characteristics with something that is really qualitative. That which is qualitative – conscious – is, for Bergson, by nature not susceptible to measure. Measure is proper only to that which is spatial: that is quantitative. To suggest, furthermore, that one could measure intensive states by the 'measurable causes which have given rise' to them, he shows is equally untenable, in practice, and obviously impossible with respect to deep-seated conscious phenomena which have arisen within us and not in response to anything outside, and are therefore as immeasurable as their effects.

It is the quality of causes that affect the intensity of conscious states, and never their measure. From a scientific realist perspective, there are clear objections to this assertion, on the basis that, as Bergson puts it, one might surmise that 'every state of consciousness corresponds to a certain disturbance of the molecules and atoms of the cerebral substance, and that the intensity of a sensation measures the amplitude, the complication or the extent of these molecular movements.'[34] But these biological and synaptic-electrical arguments, concerning spatial, measurable reality that is susceptible to the scientific method, occur on the mechanical 'outer' to our conscious 'inner'. As Bergson says, 'it is the sensation which is given to us in consciousness, and not this mechanical work'.[35] More fundamentally, for Bergson, this is a misapplication of the measurable quantity of an external influence – to what is, by contrast, a qualitative inner experience.

In short, ascribing spatial, quantitative characteristics to the qualitative nature of conscious states involves, for Bergson, a misunderstanding of the nature of consciousness. Bergson describes how, for example, deep-seated feelings are not a single feeling that has somehow grown large – a view that would wish to measure the growth – but a feeling which has spread itself into many parts of our consciousness, whereby our experiences of all kinds of things are newly tinged with this deep-seated feeling, whose 'image has altered the shade of a thousand perceptions or memories'.[36] This is particularly true of aesthetic feelings, where Bergson finds that 'the feeling of the beautiful is no specific feeling' but more a state wherein 'every feeling experienced by us will assume an aesthetic character, provided that it has been *suggested,* and not *caused*.'[37] We are uplifted by these feelings: indeed, our step feels lighter, our aspect brighter.

Now, muscular effort is clearly somehow involved in even the deep-seated emotions described above. But Bergson asserts that, 'We are conscious not of an expenditure of force but of the resulting muscular movement.' [38] Even when an amputee strives to move a missing limb, although no movement can take place in that limb, there is an experience of effort, for a host of other muscular movements are put in motion throughout the body, right up until the part where the nerves that would have controlled that limb lose their connection. Indeed, all emotions – from the deep-seated states up to abject fear or rage – involve the movements of our muscles, sinews, nerve-endings and skeletal structure to some degree. Our perception of the intensity of such muscular effort, however, is what is in question. Bergson's argument is about the distinction between conscious quality and physical quantity: that the intensity of conscious states cannot be measured in physical quantities because conscious states are qualities not susceptible to measure. Sensations, in the end, for Bergson, are ultimately about preference, and not calculation, and have, in the end, to do with *free will*.

The key to this is in how Bergson describes the distinction between affective and representative sensations: another explanation through the comparison between pairs. Affective sensation is commonly understood as a sensation accompanied with a strong compulsion to act on it. Representative sensation is something Bergson presents to us as being distinct from affective sensation, a kind of sensation that is an 'acquired perception;' the examples he gives of this are sound, heat and cold, pressure and weight, and light. Whilst gladly acknowledging that affective and representative sensations form something of a continuum, and that some affective element is likely still present in the most representative of sensations, and vice versa, in keeping with his characteristic methods, it is instructive for Bergson, nonetheless, to have us imagine these sensations in isolation to gain a better understanding of them, albeit that in practice they always appear in combination.

What, then, does Bergson propose that the intensity of an affective sensation, such as pleasure or pain, consists of, if not merely 'the conscious expression of an organic disturbance, the inward echo of an outward cause'?[39] Again, it is to do with the nature of consciousness. Citing the utilitarian quality of nature – with which any scientist would agree – Bergson introduces an argument concerning the utility of such affective sensations as pleasure or pain. If, as both common sense and biological interpretation would suggest, 'we' – and in this he includes the entirety of life, not just humanity – 'rise by imperceptible stages from automatic to free movements,' and the 'latter differ from the former principally in introducing an affective sensation between the external action and the volitional reaction which ensues,'[40] then such experiences as pleasure and pain, making their appearance 'only in certain privileged beings,'[41] are quite probably faculties enabling us to resist the automatic, to understand what is in preparation, what is on its way, and make a choice: in other words, 'either sensation has nothing to do, or it is nascent freedom.'[42] Here we see the entry into his arguments of the nature of free will, that which Bergson sees as perhaps the key differentiator of consciousness, for all that its primary capacity, choice, must necessarily be within the constraints of the possible.

Choice, or 'indetermination' – that which is not determined by automatic mechanical or organic laws that constrain the possible – is what enables the conscious mind to opt for one pleasure rather than another. But this brings us immediately back to the distinction between quantity and quality, when describing such an affective sensation as pleasure: 'What do we mean by a greater pleasure except a pleasure that is preferred?'[43]

Representative sensations, although it is immediately apparent that many also have an affective character, are then used by Bergson to lay out his primary argument in this discussion of conscious states: he distinguishes between spatial and measurable quantity, and durational, conscious quality. Perhaps the best example he gives is that of the difference in kind between light and brightness. The former we can measure, even if only as simply as in a number of candles we have lit. One can increase or decrease the number of candles, and thereby accurately measure the quantity of light in a room. But the experience of brightness is by contrast one of different shades and nuances of white, grey and black – related, undoubtedly, to the quantity of candles in our environment, but not so directly that one could measure this or that shade as being caused precisely by this or that number of candles. The quantity of light may change by degree, but the quality of brightness changes from one kind of intensity of feeling to another, from one nuanced state to a different one.

Table 2.1 captures for the reader many of these distinctions, in an attempt to clarify Bergson's arguments thus far. It should be remembered that most of these distinctions are about aspects of the real that are interpenetrating, indivisible, and only posited as discrete for the purpose of better understanding.

It is in particular the distinction between *degree* and *kind*, however, which for Bergson characterises all conscious states, however closely

Table 2.1 Two sides of one coin

<table>
<tr><td rowspan="2">REAL</td><td>duration</td><td>conscious</td><td>quality,
kind</td><td>mobile,
multiple</td><td>Representative
sensation
e.g. brightness</td><td>absolute
knowledge –
intuition</td></tr>
<tr><td>space</td><td>physical</td><td>quantity,
degree</td><td>fixed,
singular</td><td>Affective
sensation
e.g. light</td><td>relative
knowledge –
intellect</td></tr>
</table>

related to their more measurable external causes they may be said to be. So – albeit that they usually appear in combination – an understanding of the difference in *kind* between affective and representative sensations offers us an argument for the nature of consciousness to be something fundamentally qualitative, and fundamentally multiple. This qualitative multiplicity – the shifting states of white and grey – is for Bergson a defining characteristic of consciousness, and a primary element in his core idea of the *durée réelle,* which he then takes further through a discussion of the notion of number.

On number

Bergson's philosophical underpinning for his distinction between mobility and fixity delves down into the origins of western philosophy and metaphysics in the ancient Greeks. Here the Professor of Greek and Latin Philosophy finds – in discussion of the nature of change, and then in the discussion of the nature of number – the key to a new understanding of time, and to the misconception – the effacement – of time, in positive science.

On the paradoxes of the Eleatics

Bergson's argument rests on what he sees as an original mistake made by the Eleatics (a philosophical school founded by Parminedes) and specifically by Zeno (ca. 490–430 BCE), one of Parminedes' students, in early Greek philosophy. Socrates met the two of them as a young man, and we learn the story from his pupil, Plato, in his book about it all, *Parmenides*. Simplicius, many centuries later, also recounts the story. Zeno's own books themselves are now lost. Zeno is best known for his paradoxes: a set of philosophical problems many philosophers (including Bergson) have assumed were devised to support his tutor Parmenides's doctrine that, contrary to common sense, a belief in plurality and change is mistaken; and in particular that motion is nothing but an illusion. These arguments against motion are also described in Aristotle's *Physics*. The most famous is of course the paradox of Achilles and the Tortoise. As Aristotle gives it to us, it states that, 'In a race, the quickest runner can never overtake the slowest, since the pursuer must first reach the point whence the pursued started, so that the slower must always hold a lead.'[44] In the race, Achilles gives the tortoise a head start. Zeno's paradox suggests that Achilles, however fast he runs, must first reach the place where the tortoise started, by which time the tortoise will have advanced, however much more slowly. Because however fast he runs Achilles must always first catch up to where the tortoise left off, therefore, the paradox suggests that Achilles will never catch the tortoise. Of course, this has been refuted many, many times – no less than by Aristotle himself, in the telling of the story, who says, 'the axiom that that which holds a lead is never overtaken is false: it is not overtaken, it is true, while it holds a lead: but it is overtaken nevertheless if it is granted that it traverses the finite distance prescribed.'[45]

Bergson's refutation is characteristically simple. As he put it in his Oxford lectures in 1911, 'The ancient philosopher who demonstrated the possibility of movement by walking was right.'[46] According to Simplicius, it was Diogenes the Cynic who, upon hearing the story, said nothing, but simply stood up and walked, thereby demonstrating the fallacy of Zeno's arguments. This story, albeit famous, is no doubt apocryphal, as Zeno and Diogenes were not contemporaries.[47] Nonetheless, it is interpreted by some that in fact, 'Zeno directed his arguments against the [Pythagorean] notion that space is the sum of points, and time the sum of instants. In other words, Zeno did not deny motion, but wanted to show that motion was impossible under the conception of space as the sum of points.'[48] Bergson's own argument, despite apparently supporting the more traditional interpretation that Zeno actually meant what he said, is indeed very similar. In his lectures to the University of Oxford in 1911, he told the audience: 'We argue about movement as though it were made of immobilities and, when we look at it, it is with immobilities that we reconstitute it.'[49] Movement, in such a reading, is but a series of positions. As Bergson describes in detail in *Time and Free Will,* and again in *Creative Evolution,* this misunderstanding of movement actually stems from a confusion between time and space; indeed, the 'immobilities' of which Zeno and the Pythagoeans speak are, for Bergson, at the heart of our concept of number itself.

On sheep, abstract number, and space

Bergson describes, in *Time and Free Will*, how when we think of a number, as well as conceiving the oneness of its singularity, and the multiplicity of those other numbers of which it is made, we are also conceiving the representation of something else – something which is ultimately spatial.

Taking the example of a flock of sheep – and enjoining us to count, say, 50 of them – he notes how we can only say that there are 50 sheep if we ignore their individual differences. Yet, of course, they must remain different from one another, or else they would merge into one single sheep. Even if they were all identical, they would at least differ in being at separate places in the field. Set aside the actual sheep, and concentrate just on the abstract idea of 50, and we can only conceive of 50 when there are 50 somethings set side by side – in space. 'Counting material objects means thinking all these objects together, thereby leaving them in space.'[50] The relative knowledge of number, the symbols that we use – such as 1, 2, 3, etc. – is for Bergson a set of symbols that we have abstracted from the abacus, from the playbricks of the nursery, that enable us better to experiment with number; they remain, however, what they are: symbols of objects juxtaposed together in space. These objects, moreover, as units that we may add together to make another unit, imply something profound about the nature of number: that it is discontinuous.

Every unit represents a halt, something indivisible, at the moment that we are dealing with it. Then, as we progress from one number to the next, in sequence or in equation, there is a 'jerk, [or] sudden jump'[51] by which we leave the one and arrive at the other. 'And the reason is that, in order to get a number, we are compelled to fix our attention successively on each of the units of which it is compounded.'[52] Significantly, with respect to the confusion about movement, 'The indivisibility of the act by which we conceive any one of them is then represented under the form of a mathematical point which is separated from the following point by an interval of space.'[53] These points quickly blur into lines, and very quickly come to seem like a continuity. Indivisible units, like the different sheep in the field, come to us from objects. Yet through the intellectual pursuit of arithmetic (which no longer has much recourse to the outside world) we very quickly come to see the number 50 as infinitely divisible in an infinite number of ways along a continuous line of infinite points. The abstraction of number into symbols gives an appearance of continuity through an abstract spatial line of connected points.

Thus far then, Bergson has introduced us to a concept of multiplicity, implicit in number, that is both spatial and discontinuous: as we saw with the number of sheep, a multiplicity dealing with objects that can be counted, and the abstracted version of this in the symbols of number – 1, 2, 3, etc. – which appear to us as points, and eventually as lines. This first multiplicity is simply spatial.

But there is also a second kind of multiplicity, a durational one, which Bergson gives to us in the image of the tolling of a distant church bell. We hear the sounds, and imagine the movement of the bell, toing and froing, that they represent. Yet – and here is the crucial point – because, here, we are dealing with time, we either simply grasp the sounds as a group – church bells – in which case we do not count them, or we explicitly count them, and then, although they are alike, we must separate them, and hold them in our thoughts even as they disappear. But, 'a moment in time…cannot persist in order to be added to others…. It is in space, therefore, that the operation takes place.'[54] States of consciousness, in other words, where the intervals between the sounds of the church bells remain, and can be counted – the sounds themselves having already passed – turn out to be a multiplicity that is very different from the multiplicity of objects: a temporal multiplicity, 'in which a necessary element is space.'[55]

Having shown us the difference between these two multiplicities, Bergson then succinctly encapsulates his crucial distinction between duration and space in this image of time being conceived of in spatial terms:

> To give this argument a stricter form, let us imagine a straight line of unlimited length, and on this line a material point A, which moves. If this point were conscious of itself, it would feel itself change, since it moves: it would perceive a succession; but would this succession assume for it the form of a line? No doubt it would, if it could rise, so to speak, above the line which it traverses, and perceive simultaneously several points of it in juxtaposition: but by doing so it would form the idea of space, and it is in space and not in pure duration that it would see displayed the changes which it undergoes.[56]

A crucial and fundamental point is reached here concerning the direction of time. In mechanistic physics, on the physical side of the Cartesian divide, time is conceived of as space. By dint of this misconception, crucially, 'the idea of a reversible series in duration'[57] arises, and in the terms of mathematics and mechanical science the reversibility of such spatial time seems both inevitable and commonsensical. An operation represented in the symbols of measure can flow in either direction. Yet, in conscious terms, as common sense can clearly grasp, if we instead conceive of time in terms of duration, time is not reversible at all – or only in the novels of H. G. Wells and the fantasies of science fiction.

So it is not just the confusion of quantity and quality, as seen in the discussion of the intensity of conscious states, but also the confusion of time and space in our conception of number, that characterises our intellectual misunderstandings of the real, in Bergson's thesis. Teasing out the distinctions between quality and quantity, between time and space, between affective and representative sensations, between time conceived spatially and reversibly and the lived experience of irreversible duration, Bergson shows us that the confusions in philosophy, and in the perspectives of mechanistic science, derive from thinking of the one half of these pairs in the terms of the other. The quality of durational, conscious, representative sensations cannot be thought of in terms of spatial, numerically measurable, affective quantities. These two halves of the universe are different in *kind*, not in *degree*, for all that they are interpenetrated, never extant without one another – ultimately, one. For Bergson space is quantitative and measurable, whilst duration is qualitative, and simply not susceptible to measure, and it is consciousness that apprehends quality and duration, and is capable of choice, of *free will*.

The experience of brightness, linked to but independent of the quantity of light, and the experience of the tolling bell – when it is grasped as a whole and lived, rather than mentally spatialised and counted like so many sheep in a field – are conscious states that occur in an irreversible unfolding of duration, an apprehension of the real that is qualitatively different from that measure of the real which science affords us. This reality which unfolds in duration is what Bergson terms the *durée réelle*, and it is in the *durée réelle* that consciousness resides, as the human corollary of that continuity: that movement which the intellectual faculty of consciousness, through mathematics, can only express as a series of stops, and fails to conceive in its ongoing indivisibility – something which common sense of course grasps *intuitively*.

Conscious living matter, understood in this way, becomes a centre of what Bergson terms 'indetermination' – the possibility of choice, our ability to choose, to exercise *free will* – and therefore establishes a point where what is otherwise determined by automatic laws may be interrupted and new directions taken. 'Let us posit that system of closely-linked images which we call the material world, and imagine here and there, within the system, centres of real action, represented by living matter.'[58] Real action is undertaken by conscious beings. One might equally describe 'indetermination' as autonomy. Yet Bergson is specific that these are conscious agents, with real choice, in the place of 'spirit' as opposed to 'matter', albeit that spirit and matter are one.

In his next major book, he addresses the nature of perception and memory, and through it grants us the clearest yet of his notions of the nature of consciousness.

On memory and perception

Bergson's ground-breaking work of the last decade of the 19th century, *Matter and Memory*, 'affirms the reality of spirit and the reality of matter, and tries to determine the relation of the one to the other by the study of a definite example, that of memory.'[59] Although on the face of it a dualistic philosophy – like that of Descartes – Bergson nonetheless succeeds in providing us with a monistic philosophy where matter and spirit (consciousness) are in fact two sides of one coin.

Bergson's argument in this book is thus about the relation between the soul and the body – addressing the classic Cartesian dualism problem in philosophy, which he seeks to confront without suggesting a divinely created spirit in man (as Descartes had done, differentiating it and setting it to one side), but to suggest to us, nevertheless, that the profundity of human nature is beyond what mechanistic science and the philosophy of the 19th century could envision. He contends that previous philosophical approaches to this problem have mostly proposed some vague thesis of union between the two, without ever being particularly precise. Ideas current in Bergson's era, then, he tells us fall into two categories: epiphenomenalism and parallelism. The first – still perhaps the default position of scientific realism and most neuroscience to this day[60] – suggests that thought is a function of the brain, that consciousness is somehow an epiphenomenon of the brain, a non-functional supplement that is caused by brain events but has no causal effect upon brain events. The second suggests that mental states and brain states are merely two languages for the same thing. For Bergson neither of these explanations is satisfactory. He certainly believes there is a connection between brain and mental states but denies that this implies a parallelism. Memory, he suggests, is the key to unlocking this problem, as it is situated at the intersection of mind and matter. Contrary to the assumptions of neuroscience, for Bergson, memory is not – cannot be – physical. If memory is not physical, then much else that goes on in consciousness – and indeed, one might add, unconsciousness[61] – must be of a similar ilk, and then we are faced with something that is not physical, which is not matter, but which is intimately associated with and couples to it.

Philosophically, in this argument, I argue again that Bergson pioneered what later the French poststructuralist, Jacques Derrida, would term a 'deconstructive' approach.[62] Deconstruction aims to espy any binaries – for example subject/object, male/female, symbolic/imaginary, rational/emotional – and to contest the normative dominant in such pairs, preferring to show the dependency of the dominant upon the supposedly subservient half of the pair, and through the deconstruction of the assumptions and knowledge systems that set up such binaries show the fluidity between them, how one becomes the other from particular perspectives. Bergson achieves this in *Matter and Memory* with nothing less than Realism and Idealism, between the belief that our reality is ontologically independent of our experience, and the belief that human experience providing us with the only window we have upon the world, cannot tell us if anything external to that experience exists.

On realism and idealism

Bergson addresses the Idealism/Realism debate in the following way: he applies his deconstructive method to the two positions, questioning the Idealist's view that somehow representations of everything in the universe exist inside our heads, and, equally, questioning the Realist's view that our consciousness has no part in it. At root, for Bergson, both are making the same mistake, assuming that perception offers a pure knowledge of the real. By contrast, Bergson asserts, perception is an integral part of how conscious beings are situated in the material world, and, once situated in context, it is clear that perception offers a contingent, and not a pure, knowledge of the real. We perceive what is useful to us – not the whole thing, but more than just a representation: what Bergson terms an 'image.' The flow of time, and the nature of consciousness and choice, determine what is useful, and that is what we perceive.

In deconstructing this realist/idealist divide, Bergson quickly establishes the truth of both consciousness and of external reality: if the nerves that convey perception to one's consciousness are cut, it is perception which vanishes, not one's consciousness *or* the object being perceived. One remains conscious, and the object continues to exist, and these two states remain distinct, but connected. The realist's world of objects does exist, but so too does the idealist's world of the mind. But for Bergson, the conscious mind is clearly more than just some kind of clever camera, passively receiving a reality that is entirely outside the mind, determined entirely by the outer flow of existence. On the contrary, the richness of the 'inner life' we all experience, and the variety of choice, desire, and agency expressed by it in the ways in which we engage the 'outer' world make such a 'realist' position untenable. Equally, however, to suggest, as Berkeley and other idealists have done, that the only reality is within the mind, is just as reductive and distorting.

This requires us to reimagine reality in terms other than those of the realist and the idealist. Both the body and other objects – all matter, in short – Bergson describes as 'an aggregate of images.' By 'image' he means 'a certain existence which is more than that which the idealist calls a representation, but less than that which the realist calls a thing – an existence placed half-way between the "thing" and the "representation".'[63]

Bergson takes issue with the Idealist's conception that representations of the outside world exist within our minds. For this to be the case the entire material universe would have to exist in our heads, which it plainly does not. The brain is part of the material universe, not the other way around. 'Itself an image, the body cannot store up images, since it forms a part of the images; and this is why it is a chimerical enterprise to seek to localise past or even present perceptions in the brain: they are not in it; it is the brain that is in them.'[64] Matter thus becomes 'the aggregate of images, and perception of matter these same images referred to the eventual action of one particular image, my body.'[65] Importantly, the most significant 'image' of all *is* our own body, which we perceive both from the outside – for example looking at our hands – and from the inside – our 'affections'. The body is the 'privileged' image that both perceives and is perceived. The body's perception of the external world, moreover, is directly relevant to what actions are possible: 'The objects which surround my body reflect its possible action upon them.'[66] Cut the nerves that convey this information – as we saw a moment ago – and the rest of the body, and the external universe, remain, although perception vanishes. There is, then, an objective reality outside of the body. Cutting the nerves merely stops the flow of information from the periphery, into the brain, and back to the periphery, and no more possibilities of action appear. 'Here is something which concerns action, and action alone.'[67]

Thus, Bergson states the problem of the realist position on matter, and the idealist position that counters it, in the following terms: 'How is it that the same images can belong at the same time to two different systems, the one in which each image varies for itself and in the well-defined measure that it is patient of the real action of surrounding images, the other in which all change for a single image, and in the varying measure that they reflect action of the privileged image?'[68] He takes these two opposites, finds what they have in common, and turns both of them inside out and upside down. What realism and idealism have in common is that they both assume, 'perception has a wholly speculative interest; it is pure knowledge.' This is posited as different from scientific knowledge. 'The one doctrine starts from the order required by science, and sees in perception only a confused and provisional science. The other puts perception in the first place, erects it into an absolute, and then holds science to be a symbolic expression of the real. But, for both parties, to perceive means above all to know.' Bergson of course disputes this. For him perception is an integral part of how conscious beings are situated in the material world, and this has nothing to do with knowing.[69] The brain cannot be isolated from the rest of the universe, made up as it is of the very substance of our bodies. Nerves that run from our fingertips to the brain and back take part in transmitting messages to and fro and the brain and its various nervous states are entirely within the universe and a part of it. Perception thus must be a physical, biological series of stimuli and electrical signals moving centrifugally and centripetally between the brain and the nerve-endings.

But if this brain-body flow only perceives and acts, who, then, does the knowing? Most importantly, who *acts*? Bergson's solution to this dichotomy is to – characteristically – talk about time and motion, rather than fixity, and to style the body as a centre of action, or 'indetermination' (i.e. choice), 'an object destined to move other objects' – which, because it can perform *new* actions, 'must occupy a privileged position' with regard to other objects.[70]

Pragmatic as ever, Bergson the empiricist suggests that our perception is basically choosey, that we apprehend what is of use to us. Thus the 'images' are less than the realist calls a 'thing,' but, albeit but an isolated shell of a 'thing', more than a mere representation of it: an apprehended, in-the-moment experience of the 'thing' as determined by the presence of choice, pragmatism, and the flow of time. Perception, thus, is concerned directly with action in a way that selects and isolates what is relevant, or *useful*, and ignores that which is not. This *usefulness* is key to understanding Bergson's description of perception. Objective reality, in which, as science describes to us, objects relate to one another according to rules we can deduce from them, continues without regard to us. The fact that this objective world appears to be different according to the subjective perspective of each of us does not, however, present any paradox: our subjective perception of these objects has isolated that which is *useful* to us about them, and ignores that which is not. Therefore, 'there is for images merely a difference of degree, and not of kind, between *being* and *being consciously perceived*.'[71] Our relationship with the objects we perceive is directly related to what actions we may or may not perform in relation to them – from what is good to eat to what we need to avoid bumping into.

His notion of the 'image,' too, requires an understanding of the flow of the *durée réelle* and the nature of choice for it to become clear. Objects in the 'real' world that our scientific analysis can describe and which impact upon each other, when perceived by us, can only ever be *less* than they are in their totality in order for a perception of them to reach us. Bergson's universe is infinitely joined up and connected whereby each point of the universe implies every other in its connectedness.

To perceive an object in its entirety is to perceive the entire universe! Inevitably, then, the 'mere presence' of living beings, of 'centres of indetermination' measured by the number and rank of their functions 'is equivalent to the suppression of all those parts of objects in which their functions find no interest.'[72]

The flow of time, moreover, is key to Bergson's argument, whereby consciousness is anchored in the past, engaged in the process of determining appropriate action directed towards the immediate future, in light of the past. The realist approach – as we saw earlier – has a much more determined, and reversible understanding of time. The realist approach would suggest that there are laws of nature that govern all 'things,' and in particular all action and reaction, which would imply that the future is in fact contained in the present and implicit in the past. Such realist laws place us in a very deterministic universe. Bergson disputes this with the common sense understanding that once consciousness enters the picture – when choices can be made – affect is not necessarily followed by cause: something *new* enters the universe, rendering such absolute determinism false. The 'things,' moreover, that the realist clings to, are snapshots of mobility: fixity is an intellectual concept, and is only ever relative in the real.

So the Idealism/Realism debate, for Bergson, ends in this: subjective idealism seeks to derive science from consciousness; materialistic realism seeks to derive consciousness from science. But such realism seems to require some *deus ex machina* – an epiphenomenality – for perception to translate into consciousness. And idealism requires a pre-established harmony for the order of nature that coincides with our consciousness. Both positions are nonsensical. Consciousness is neither the 'epiphenomenon' of matter, as the scientific realist would have it, nor the foundation of reality, as the idealist would have it. Consciousness is, indeed, something far more interesting.

On perception, memory and action

The implications of Bergson's position on the Idealist/Realist debate, for the distinction between the mental and the cerebral, between consciousness and the brain, are profound. Our psychical life, while bound to its motor accompaniment, is, for Bergson, not governed by it. Consciousness – the ability to know, and to choose – must, on the contrary, be quite separate from the more straightforward nature of perception. Consciousness must not be physical – susceptible to quantitative measure – at all: it must be a quality, something different in *kind*.

As we saw above, Bergson maintains that the nervous system and the brain – the entire body in fact – is merely a 'centre of action'[73] where perceptions trigger reactions, which in turn trigger movement. Perceived images are thereby sketches of potential action. This purely physical, biological perception-action flow is interrupted by consciousness, to enable comparison between several different options, and choice between them, before either proceeding or shelving a reaction. Bergson uses a great deal of contemporary research into the brain, from the late 19th century, in his exposition of these arguments. Modern neuroscientific studies, such as those of Rizzolatti and Craighero, indeed, would seem to offer further proof of this conception of the body as an action centre, too. Mirror-neurons,[74] for example, turn out to behave in just such a manner: 'in humans, in addition to action understanding, the mirror-neuron system plays a fundamental role in action imitation.'[75] In other words, perception triggers responses in the brain, not only when something is actually perceived, but also when it is only consciously conceived: the same neural activity is witnessed when something is perceived as when it is remembered or imagined. The brain is thus the action centre, ready to proceed or shelve a reaction to perceptions – whether from the external world or from consciousness. This is entirely in keeping with a Bergsonian understanding of the brain as a centre of action – and of consciousness that is the origin of choice.

So, if perception – linked to the perception-action flow in a biological chain from the external object on the periphery to the action centre in the brain, and thereby back through the nervous system into action – is limited to what is useful, and is essentially physical – a part of the material world, and something which is interrupted by consciousness in order that a choice may be made – what, then, is consciousness? For Bergson it can only be something that is *not* material, that is different in *kind* from the matter that it interrupts, albeit but one side of the coin of existence. 'I will not give a definition,' of consciousness, he says in a later essay, 'for that would be less clear than the thing itself; it means, before everything else, memory.'[76] 'Memory' he continues, 'may lack amplitude; it may embrace but a feeble part of the past; it may retain only what is just happening; but memory is there, or there is no consciousness. A consciousness unable to conserve its past, forgetting itself unceasingly, would be a consciousness perishing and having to be reborn at each moment: and what is this but unconsciousness?' All consciousness, then, for Bergson, is memory, the 'conservation and accumulation of the past in the present.'[77] In *Matter and Memory* Bergson expounds upon this in detail.

Using his characteristic supposition of two extremes which do not occur in reality, but whose mixture is better understood if we imagine them, for a moment, apart, he posits two things: pure perception, and pure memory. Pure perception, he argues, is always in the absolute present, intuitively grasped, and existing ultimately outside of us – in the objects that we perceive. Pure memory, by contrast, is entirely in the past. Of course, as Bergson asserts, 'There is no perception which is not full of memories. With the immediate and present data of our senses we mingle a thousand details out of our past experience.'[78] But in order to understand the nature of consciousness, and how it relates to perception, Bergson enjoins us to imagine not just a pure perception, but a pure memory.

Now, the sheer quantity of memory would be impossible to somehow store, chemically, biologically, within the brain. Most of what we know about memory, in scientific circles, comes from problems with memory – in particular, cases of brain injury where partial memory loss has resulted. These kinds of experiment, and case histories of brain-injured patients, were already well under way in the late 19th century, and Bergson uses a great range of such scholarship in his argument. In particular, the idea that recognition precedes recollection – a favourite among many scholars studying the subject both then and now – is refuted by Bergson.[79] Among others, he puts forward the case where the visual memory of a town a patient had lived in was easily recalled, eyes shut, and described in detail, yet when the subject was placed in the town itself, she did not know where she was, and could not find her way.[80] Recognition, then, in this case, could neither precede, nor indeed be particularly important, in the process of recollection. He cites other, similar, cases too.

Recent medical scholarship, indeed, remains undecided regarding the 'storage' of memory. Electrical activity in the hippocampus, associated with the recollection of episodic memory,[81] *could* be commensurate with physical storage in the hippocampus of specific memory types (although it seems as memories get older they are transferred to the frontal cortex); *or* –as Bergson argues – this activity could equally well be associated with the brain processes involved with recollection, rather than actual storage. Is recollection, in other words, a process of retrieving a physically stored representation from within the neural networks of the brain, or a process of looking back into the past? Is the physical, measurable activity associated with a process such as an affective sensation (that is the corollary of a non-physical, representative sensation, the conscious experience) something which is different in *kind* rather than in *degree*? The question, in short, comes down to this: the fact that activity can be measured with functional MRI (fMRI) scanning when a subject stares at a screen with the word 'Ketchup' on it is not proof that the memory of the word 'Ketchup' exists in some representation of 'Ketchup' in some bioelectrical form within the brain – be it a neural sheet of paper in a neurological filing cabinet or a series of blocks of 0s and 1s on a hippocampal hard disk. Neither image is sufficient for the sheer quantity of what memory is capable of, nor is the concept of such representationalism – the world of the past represented as files in the brain – philosophically sound. For Bergson, it is simply not possible that the brain could 'store' somehow the immense detail that is possible with memory.

Memory, moreover, for Bergson, is the key aspect of consciousness that makes it what it is. Now, there are, for Bergson, two forms of memory. As he puts it, 'The past survives under two distinct forms: first, in motor mechanisms; secondly, in independent recollections.'[82] Thus, there is the form of memory that can perhaps best be understood as habit – something that has been learned and need no longer be conscious. But there is another form of memory that brings to consciousness distinct recollections of specific events. These two kinds of memory differ fundamentally with regard to action: the former indeed is more properly understood as part of the present, an action in the now that the body has recorded through practice; the latter exists only in the past, has no engagement with action or the body in the present. The distinction is crucial. One might understand habit, for example learning by rote, rendering automatic, as memory. But each individual time that we go through something in order to learn it is also an individual memory. There is a distinction therefore between what we have learned to repeat – as a motor mechanism – and what we simply remember because we did it, because it happened. The former, in fact, 'no longer *represents* our past to us, it *acts* it; and if it still deserves the name of memory, it is not because it conserves bygone images, but because it prolongs their useful effect into the present moment.'[83]

Pure memory, on the other hand, is something quite different. To understand this, we must follow Bergson in his durational imagery concerning the process of remembering. Memory and recollection are not an object retrieval system, for Bergson, but a temporal field of awareness, which can expand or contract depending on requirement. Imagine a cone of memory stretching back in time, from the point of the present, into all that which has come before. Imagine reaching, by expanding your awareness of the past, back into it, gradually immersing your consciousness in the remembered experiences. Having found what you seek, this process of immersion can then begin to pull the past forward from memory into your present consciousness. Yet by doing so you will inevitably make that past a part of your present: you will begin to perceive its sensations in the now. In this way the process of recollection makes of memory a new experience, a new perception. But thus all too soon that new perception becomes a new memory, of the time that we remembered, and of the effect that this had upon us. The recollection (which is in the present) and the memory itself (which is in the past) are then quite different: the present recollection is a perception; the memory itself, in the past, is memory alone: pure memory.

In short, in Bergson's summary, 'in the degree that these recollections draw nearer to movements, and so to external perception, the work of memory acquires a higher practical importance. Past images, reproduced exactly as they were, with all their details and even with their affective colouring, are the images of idle fancy or of dream: to act is just to induce this memory to shrink, or rather to become thinned and sharpened, so that it presents nothing thicker than the edge of a blade to actual experience, into which it will thus be able to penetrate.'[84]

So the present – pure perception – is a physical consciousness of the body. The past – pure memory – is an unconsciousness of the body, the realm of fancy and dream. The reality of the human condition is always a blend of the two. Memory, in the human being, is something that gives the flow of our perceptions from periphery through the centre to periphery, the possibility of choice. We can pause, in the centre of action that is our body, and compare the motor mechanism action ready to react to our perceptions with previous ones, in our memory, and weigh up the pros and cons of different outcomes. We may, indeed, choose not to act at all, which is where Bergson refers to the 'virtual' – actions that are potential, neither occurring, nor merely memory. Libert's experiments[85] in recent decades show decision-making in laboratory conditions – whether to lift the right hand or the left, for example – taking place in measurable brain activity seconds before such a decision has become conscious. For Bergson the 'deep self', where we are a 'centre of action', is located closer to memory than to perception, and thereby nearer to the past than to the present. Decisions, then, of this more *intuitive* kind would precede their rise into the more intellectual, perceptive conscious self. Most significant here, however, is that these separations and distinctions are not absolute, but merely useful: all is, in reality, fluid, interpenetrating, one.

Herein, indeed, lies the combination of perception and memory which constitutes the norm, as opposed to the extreme forms of 'pure perception' and 'pure memory.' What we actually perceive, then, is always a mixture of 'pure perception' – coming to us from our senses, ready to translate into action – and the images from memory that we project upon the objects we are perceiving, pausing action for the possibility of choice. Indeed this mixture has been the subject of recent scholarship. The mix of perception and memory in our experience of the world is underlined by another group of modern neuroscientists[86] who also assert that a good proportion of our experience of the external world is in fact projected. Professor Llinás would have it, from his studies of dreaming and wakefulness, that our brains are actually in an almost constant state of dreaming – 'they are continually generating images to manufacture the world inside our heads,' he asserts. 'The outside world is a projection, you put it there. It is not happening out there, it is happening inside your head. It is, in fact, a dream, exactly like when you fall asleep. We need to see, we need to perceive, we need to dream actively – because this is the only way we can take this huge universe and put it inside a very tiny head. We fold it, make an image, and then we project it out.'[87] Perhaps an extreme view, but certainly one that underlines how the projection from memory, as Bergson describes, colours our experience of the external world. Imagination and normal vision, it would appear, are separate but overlapping brain processes, and our visual experience 'is a kind of mixture of information coming in from the eyes and prior association.' In short, 'we see things with our brains, not our eyes.'[88] Llinás, indeed, even suggests that the brain evolved because organisms needed to move around without running into other organisms or objects.[89] For Bergson, too, vision is a key characteristic in the evolution of all animals. In similar vein, Gregory asserts that, 'Perception seems, then, to be a matter of 'looking up' stored information of objects, and how they behave in various situations,'[90] in order to make decisions about how to react to them.

At this junction, then, between memory, perception and action, 'the hyphen which joins what has been to what will be,'[91] consciousness acts as a bridge between the past and the future, neither a part of the physical, objective world of perception, nor wholly divorced from it in the temporal field of the past. For Bergson, consciousness is that which exists in the moment, in the *durée réelle* that links past and future, and can only be something on the other side of a dualistic conception of existence: on the one side matter, on the other, for want of a better word, spirit. Yet unlike any other dualistic conception of existence, unlike nearly every other conception of 'spirit', these two are never apart, never distinct, always indissolubly concurrent, coexistent, and

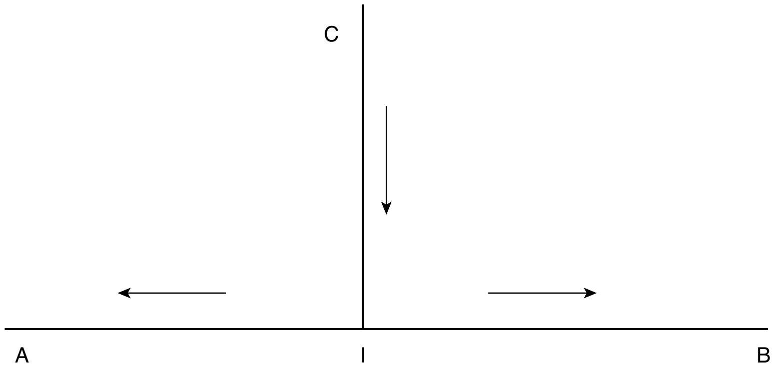

Figure 2.1 A diagram from *Matter and Memory*

coterminous. The very moment this dualistic conception of existence – matter and spirit – is posited, as it were, it is immediately merged into a monistic conception.

Bergson places real duration, or *durée réelle*, then, at the point 'I' in Figure 2.1, experienced by our consciousness as it rides the unfolding universe at the fulcrum of past and present. He outlines the relation between space and time thus: 'Our perceptions, actual and virtual, extend along two lines, the one horizontal, AB, which contains all simultaneous objects in space, the other vertical, CI, on which are ranged our successive recollections set out in time. The point I, at the intersection of the two lines, is the only one actually given to consciousness.'[92]

The survival of the past, by which memory is possible, is therefore not physical: it is not in the brain. It is not – cannot be – contained by the body. 'The fundamental illusion consists in transferring to duration itself, in its continuous flow, the form of the instantaneous sections which we make in it.' The past does not cease to exist, it ceases to be useful. It is wrong to define the present 'as *that which is*, ... the present is simply *what is being made*.'[93]

Bergson is emphatic about this, using an extraordinary image to present his case:

> In the fraction of a second which covers the briefest possible perception of light, billions of vibrations have taken place, of which the first is separated from the last by an interval which is enormously divided. Your perception, however instantaneous, consists then in an

> incalculable multitude of remembered elements; and in truth every perception is already memory. Practically we perceive only the past, the pure present being the invisible progress of the past gnawing into the future.[94]

On indivisibility and movement

With time thus conceived as *durée réelle,* we are confronted with the inevitability that our conception of movement must also be altered. For Bergson, then, 'Every movement, inasmuch as it is a passage from rest to rest, is absolutely indivisible.'[95] The image he uses to describe this is the movement of one's arm:

> Here, for example, is my hand, placed at the Point A. I carry it to the Point B, passing at one stroke through the interval between them. There are two things in this movement: an image which I see, and an act of which my muscular sense makes my consciousness aware. My consciousness gives me the inward feeling of a single fact, for in A was rest, in B there is again rest, and between A and B is placed an indivisible or at least undivided act, the passage from rest to rest, which is movement itself. But my sight perceives the movement in the form of a line AB which is traversed, and this line, like all space, may be infinitely divided. It seems then, at first sight, that I may at will take this movement to be multiple or indivisible, according as I consider it in space or in time, as an image which takes shape outside of me or as an act which I am myself accomplishing. Yet when I put aside all preconceived ideas, I soon perceive that I have no such choice, that even my sight takes in the movement from A to B as an indivisible whole, and that if it divides anything, it is the line supposed to have been traversed, and not the movement traversing it.[96]

The issue Bergson is getting at here, is that the line is a product of the intellect, and that we should not 'confound the data of the senses, which perceive the movement, with the artifice of the mind, which recomposes it.'[97] Here Bergson is the Lucretian fighting off the Platonic forms, the empiricist adamant that the testimony of the senses must trump the rationality of the mind. The division of the line we perceive a movement to have traversed is the 'work of our imagination, of which indeed the office is to fix the moving images of our ordinary experience, like the instantaneous flash which illuminates a stormy landscape by night.'[98] It is, to use the image Bergson introduces in

Creative Evolution, the illusion of the cinema:[99] cinematography, since its inception, has provided us with the illusion of movement by dint of the rapidity of exposure to a sequence of still images. We *know* in the cinema that this is an illusion, that reality is *not* like this. Yet in our everyday thinking we persist in imagining that the unfolding of time can be understood on the metaphor of the cinema, that somehow reality unfolds rapidly from one stillness to the next, too fast for us to notice. Bergson claps his hands, urging us to wake from this illusion: 'how should a *progress* coincide with a *thing,* a movement with an immobility?'[100] The movement and the line of trajectory which it traces are different in *kind,* and we cannot divide the one in the same manner that we can divide the other.

It is our conscious distinguishing of moments in the course of duration that facilitates this illusion, but Bergson shows us lucidly both why we attribute such instants to duration, and why such instants cannot exist. He takes us back to Zeno and the Eleatics, and the Pythagorean notion of a universe made up of points, and the grand paradox of Achilles and the tortoise. Trying to make time and movement coincide with the line that underlies them, which is precisely what the illusion does, is the root of the paradox; allowing movement to rise free from such attempts at spatial divisibility, such anchoring upon points in space, is how we understand that Achilles must overtake the tortoise. The illusion, for Bergson, is of course *practical,* and *useful,* for our common sense. Understanding movement to be as divisible as the line of trajectory that it carves in front of us satisfies both our need to see how movement describes a space, and our anticipation that at any 'point of this space the moving body *might* stop.'[101] But, just as Achilles *will* overtake the tortoise, movement is *in fact* not a sequence of stops, but an indivisible continuity.

So, for Bergson, 'there are real movements,'[102] and '*none of our mathematical symbols can express the fact that it is the moving body which is in motion rather than the axes or the points to which it is referred.*'[103] Measurement, in short, which can only express distances, cannot trap motion. This conundrum indeed lies at the heart of some of the deepest of philosophical debates. Bergson points out how Descartes speaks of movement as reciprocal, whilst at the same time formulating laws of motion 'as though motion were an absolute' – a contradiction Bergson reminds us Leibniz also remarked upon.[104] But if there is absolute motion, as Bergson points out, 'is it possible to persist in regarding movement as nothing but a change of place? We should then have to make diversity of place into an absolute difference, and distinguish absolute positions in an absolute space.' The contradictions of heterogeneous and homogeneous spaces resulting from such a proposition become an impossibility. 'We cannot, then, hinder ourselves either from holding every place to be relative [*viz* Einstein], or from believing some motion to be absolute.'[105] It is here that Bergson's thinking sets him on a collision course with the temporal implications of Einstein's theory of relativity, to which he devoted his book, *Duration and Simultaneity*, and which I shall address in Chapter 5. For now, it is sufficient for the purposes of this chapter to conclude that Bergson's understanding of motion implies a third proposition: 'all division of matter into independent bodies with absolutely determined outlines is an artificial division.'[106] Certainly the microphysics of quantum theory would agree with Bergson here, as we shall see in Chapter 5.

We have seen already, in discussion of the nature of perception, how the outlines of objects are to be understood in terms of their practical usefulness for the perceiver. Place these outlines and this usefulness in the undivided flow of the *durée réelle* and it becomes clear that a '*moving continuity* is given to us, in which everything changes.'[107] It is only our needs, like so many 'search-lights, which, directed upon the continuity of sensible qualities, single out in it distinct bodies,'[108] which science then can study and interpret for us. In the end, then, Bergson is able to confirm to us that 'real movement is rather the transference of a state, than of a thing.'[109] Ultimately, movement is *quality*, opposed to space, which is *quantity,* and the two must be seen as fundamentally different in *kind:*

> The duration lived by our consciousness is a duration with its own determined rhythm, a duration very different from the time of the physicist, which can store up, in a given interval, as great a number of phenomena as we please. In the space of a second, red light – the light which has the longest wave-length, and of which, consequently, the vibrations are the least frequent – accomplishes 400 billions of successive vibrations. [110]

Given that, in Bergson's era, the smallest interval of time we could detect was one 500th of a second, to count each vibration of red light successively would take twenty-five thousand years. 'We must distinguish here between our own duration and time in general. In our duration – the duration which our consciousness perceives – a given interval can only contain a limited number of phenomena of which we are aware.'[111]

Fundamentally, if our conscious duration – our living in the *durée réelle* – perceiving the objects around us as fixed merely for practicality, when they are in truth 'numberless vibrations, all linked together in uninterrupted continuity, all bound up with each other, and travelling in every direction like shivers through an immense body,'[112] then Bergson's universe indeed comes to resemble something closer to the subatomic unobservables of quantum physics, where all concept of fixity dissolves into charged energies and where geometric spatial analogies collapse into uncertainty. We will revisit this quantum universe in Chapter 5. Suffice to say now that, for Bergson, our consciousness perceives the geometric only by dint of *necessity.*

> If there are actions that are really *free,* or at least partly indeterminate, they can only belong to beings able to fix, at long intervals, that becoming to which their own becoming clings, able to solidify it into distinct moments, and so to condense matter and, by assimilating it, to digest it into movements of reaction which will pass through the meshes of natural necessity. The greater or less tension of their duration, which expresses, at bottom, their greater or less intensity of life, thus determines both the degree of the concentrating power of their perception and the measure of their liberty.[113]

Bergson's *Matter and Memory,* then, presents us with a picture of the universe that is perceived, and of the consciousness – memory – which acts within it, in its own duration, all distinct – different in *kind* – from the measurement of space, and of spatialised time, with which we are familiar from our intellectual pursuits such as mathematics and scientific parlance. Choice and freedom will lie at the heart of this distinction. We must therefore add, to our table of distinctions Bergson makes in his characterisation of the real, the distinction between movement and trajectory (Table 2.2).

Table 2.2 Two sides of one coin (ii)

<table>
<tr><td rowspan="2">REAL</td><td>conscious duration</td><td>quality, kind</td><td>mobile, multiple</td><td>movement</td><td>representative sensation e.g. brightness</td><td>absolute knowledge, intuition</td></tr>
<tr><td>physical space</td><td>quantity, degree</td><td>fixed, singular</td><td>trajectory</td><td>affective sensation e.g. light</td><td>relative knowledge, intellect</td></tr>
</table>

On the *Élan Vital*

In his most famous book, *Creative Evolution*, first published in 1907, Bergson addresses the problem of evolution. He does so as a philosopher armed with the notions of *intuition philosophique*, *durée réelle*, and his conceptions of perception and memory, and not as a biologist. This is the focus, too, of the present volume, and we will revisit many of the ideas laid out here as the book unfolds. After considering the support in quantum theory for Bergson's notion of time, the primary argument in Chapter 5 concerns the philosophical support that I see in Bergson's ideas, for the arguments of the complexity theorists in evolutionary theory, and some suggestions for them too. Nonetheless, some elements of this must be introduced here, in order to situate the arguments put forward by Bergson in this core text, *Creative Evolution,* in their proper context.

It will be useful, therefore, to begin this section with a brief overview of some of the terms, issues, and problems of evolution that both Bergson and complexity theory, in their differing – and, I argue, often very similar ways – try to address.

Definition of terms

Without attempting to be exhaustive, or to present a 'scientific' overview, it will nonetheless be helpful for the purposes of this philosophical argument to outline what is meant by some of the terms I will be using, and to briefly review some of the history of evolutionary thought, and Bergson's place within it.

Modern biology, despite antecedents going back into ancient Greek work (in particular, Aristotle) can probably best be traced to the 18th century, and the *taxonomy* of Carl Linnaeus. His standardised naming system for animal and plant species, known as the Linnaean system, is still used in essentially the same way, to this day, albeit modified by the 20th century taxonomic ordering concept of the *clade*: a group of animals or other organisms derived from a common ancestor species. In contemporary biology, it is believed that there are somewhere between five and 30 million species in total, dispersed in tens of thousands of local systems, called *ecological communities* or *ecosystems,* of which there are about 30 major kinds, called *biomes* – for example tropical rain forests, coral reefs, grassland.

This classification of the living world is thus also concerned with development, and includes two principal timescales: *ontogeny,* which relates to development during the life cycle of an organism – the organismic timescale – through pregnancy and birth and on through puberty to parenting, and variations on this scale that form *microevolution*; and *phylogeny*, which relates to the development, descent, and branching of species over evolutionary timescales, or *macroevolution,* as traced and mapped out by the taxonomic ordering practice of *cladistics*. In the context of phylogeny, there is also *speciation*: the development of new species.

These are givens in biology and in evolutionary theory. The precise processes or mechanisms of evolution, however, are what are principally at issue, although the arguments around these processes also impact upon the status of taxonomic classifications. Bergson's characteristic durational approach, focusing on multiplicities and process, will already imply, for the reader, that any taxonomy must bear caveats concerning: firstly, where the line is precisely to be drawn between one species and another; and secondly, in the continuous process of evolution, where the process of speciation may be said to begin and end. These arguments are not just Bergson's, but his take on them in *Creative Evolution* is characteristically challenging. A 'species' must be viewed, in this light, as a useful classification of something both imprecise and continually in process, rather than anything essential, fixed, or stably discernable.

Charles Darwin's evolutionary theory deals with the timescales of both ontogeny and phylogeny – the organismic and evolutionary timescales. The mechanisms of Darwin's evolution are *variation* and *natural selection*. Variation describes the multiplicity just alluded to, whereby a range of traits may be accurately attributed to a species, in contrast to there being any one set of ideal traits all members of such a species conform to. A species' population will include a range of such traits, with some more common than others.

Darwin's view was that accidental mutation was at the root of these variations. As he says, in *Origin of Species,* 'It is, indeed, quite futile to look to changes of currents, climate, or other physical conditions, as the cause of these great mutations in the forms of life throughout the world, under the most different climates. We must … look to some special law.'[114] This special law he defined as natural selection. As he put it, the 'preservation of favourable variations and the rejection of injurious variations, I call Natural Selection.'[115]

In contemporary evolutionary biology, these ideas of Darwin's are – at the least – much more nuanced. The notions of *fitness* and *niche* have taken on great importance. Not only are species themselves recognised as things that are in process, but the environments in which species live are recognised as things which are not static. Environments are also therefore now recognised as having far greater impact upon the variations within species than Darwin was prepared to allow. It is now recognised, too, that some of the changes that are ongoing within environments are themselves caused by the species living within them. Thus, the variations in a species that are more likely to be 'selected' over time are not necessarily those that are intrinsically 'best' for the species, but are more likely to concern how well such mutations or variations *fit* the current environment. Equally, the environment itself may in part be carved out as a *niche* environment by species or groups of species, as their activity impacts upon the changes that environments undergo in the process of time.

Nor, indeed, is there agreement amongst all evolutionary biologists on the adaptationist interpretation outlined above. There are arguments that some variations are not adaptations at all, but merely the unintended consequences of other adaptations, the accidental by-products of selected traits.[116] Such accidental selections – fitness, the creation of niche environments, and the co-evolution of species whose sharing of environments trigger variation selections in each other – all go to making Darwin's 'special law' of natural selection a much watered-down affair in contemporary evolutionary biology, even before any consideration of the most fundamental development in biology since Darwin's time: genetics.

Darwin was concerned with organisms. Some of today's evolutionary biologists have almost completely effaced the organism and concentrate exclusively on the genetic level as the sole arena of evolution: genes are treated as the *units of selection*, rather than organisms. Yet even here there is controversy, for it transpires that the *expression* of genes is more important than whether they are present or not in the DNA of a particular species or individual organism. The expression of genes – whether or not they trigger this or that protein or the expression of this or that other gene – turns out to be at the intersection of immensely complex networks of influences that include the environments in which the organisms containing such DNA are living.[117] For yet other biologists, it is neither the organisms nor the genes that should be considered as the units of selection, but the species, or grouping of individuals within a given range of traits.[118]

As we shall see in Chapter 5, this much watered-down 'special law' of Darwin's, natural selection, is now, in the eyes of some evolutionary biologists, not even regarded as the *primary* driver of evolution, as Darwin believed, but only as something secondary, which impacts upon the first. This is a very revolutionary proposition; as revolutionary, in fact, as Darwin's was in the first place. All the pre-Darwinian evolutionary theories – Lamarck's in particular – posit a primary force of linear progress, to which is added, for some, a distinctly secondary force of adaptation. Evolutionary theories, then, break down into essentially two groups: the *formalist*s, whose approach is also described as structuralist, who propose a line of progress; and the *functionalists,* whose approach is also described as adaptationist, epitomised by Darwin's natural selection theory. Orthogenesis is a group of approaches that attempt to combine both formalism and functionalism in one way or another, though the presence of formalism within such theories is –by definition – uppermost. Early orthogenetic theories, in the latter part of the 19th century – from Eimer, who coined the term, through to Bateson – either rejected natural selection altogether or gave it only minimal modifying capacity.[119] Both Bergson, at the turn of the century, and the contemporary evolutionary biologists influenced by complexity theory, could be said to be proponents of a form of orthogenesis, as their ideas include a formalist, uppermost element, but who nonetheless defend natural selection for their secondary functionalism.

Darwin's radical break with the formalist, or structuralist tradition of his forbears was to deny 'the existence of a primary progressive force, while promoting the lateral force of adaptation to near exclusivity.'[120] This was the cornerstone of what Gould describes as the three primary pillars of Darwinian evolutionary theory: '*agency*, or the claim for organismal selection as the causal locus of the basic mechanism ... *efficacy*, or the claim that selection acts as the primary creative force in building evolutionary novelties ... [and] ... *scope*, or the claim that these microevolutionary modes and processes can, by extrapolation through the vastness of geological time, explain the full panoply of life's changes in form and diversity'.[121] It is also worth noting the *gradualist* approach of Darwin, against any kind of *saltation*, or sudden development from one generation to the next: Darwin 'passionately defends the central role of variations so small as to pass beneath nearly everyone's notice.'[122]

Stephen Jay Gould's *Structure of Evolutionary Theory* is perhaps one of the finest tomes on the topic of evolution – and the history of evolutionary thought of the 21st century, thus far. In it Gould affirms his belief that 'the Darwinian framework, and not just the foundation, persists in the emerging structure of a more adequate evolutionary theory,'[123] before proceeding to lay out the modifications required to make Darwinism adequate in the face of developments in evolutionary biology since the mid-19th century. In so doing he reaffirms the primacy of natural selection, before nonetheless declaring contemporary evolutionary theory basically different:

> substantial changes, introduced during the last half of the 20th century, have built a structure so expanded beyond the original Darwinian core, and so enlarged by new principles of macroevolutionary explanation, that the full exposition, while remaining within the domain of Darwinian logic, must be construed as basically different from the canonical theory of natural selection, rather than simply extended.[124]

For Gould, the *agency* claim for organisms as the units of selection must be modified to include a hierarchy of different units, including both the genes and the species. Moreover, these levels of the genes, of the organism and of the species, must be 'decoupled' to allow for the distinctly different ways in which each level responds to evolutionary pressures. Thus, a hierarchical model of selection unfolds. This was – says Gould – admitted by all three of the 19th century forefathers of evolution, in the end, after trying in vain to make selection fit a single level: Darwin, Weismann, and De Vries – of whom the last coined the term, 'species selection'.[125] Weismann was a powerful voice in favour of natural selection, and De Vries also introduced, in his theory of pangenes, the particulate theory of heredity that eventually – with Mendel's work rediscovered and reintegrated – became genetics.

The *efficacy* claim – that selection acts as the primary creative force – must also be curtailed by recognising 'the enormous importance of structural, historical, and developmental constraint in channelling the pathways of evolution, often in highly positive ways,' rendering 'the pure functionalism of a strictly Darwinian ... approach to adaptation no longer'[126] sufficient. In other words, fitness, niche, accidental adaptations and other processes and pressures greatly temper Darwin's rule of natural selection as the only driver.

The *scope* claim – that natural selection can account for everything, everywhere, and forever – must similarly be bounded by a rejection that 'such extrapolations can render the entire panoply of phenomena in life's history,' and an assertion that the scope must include macroevolutionary pressures: such as the cladal trends that affect species, incorporated in Gould's theory of 'punctuated equilibrium'; and also the 'catastrophically triggered mass extinctions,'[127] such as the famous Cretaceous–Paleogene extinction event when an asteroid at Chicxulub wiped out the dinosaurs.[128]

Whilst essentially continuing to pay homage to the founding father of evolutionary science, Gould nonetheless thus pushes our understanding of evolution beyond an expansion of Darwinism into what is a qualitatively different theory from the 1859 original.

Now, Gould never mentions Bergson in his treatise. No doubt this is a deliberate omission, considering the number of other writers he quotes who were themselves both conversant with and quoted Bergson in their works (e.g. Morgan,[129] Haldane;[130] even Julian Huxley – torch-bearer of the *modern synthesis*, who coined the term *clade* – had to address Bergson in his foundational work[131]). We must assume that Gould never read any Bergson and subscribed to the common prejudices around his ideas.

Gould does touch, however (albeit briefly) upon the work of Kauffman: his (1993) *The Origins of Order: Self-Organisation and Selection in Evolution*; and Goodwin: his (1994) *How the Leopard Changed His Spots*. Both these authors are key to the arguments in Chapter 5 of this present volume, though in fact more substantially from Kauffman's second, (1995) work, *At Home in the Universe,* which Gould does not mention. Gould recognises their 'arguments hold substantial power for explaining some features of relatively simple biological systems,' and that 'such models also have substantial utility in describing very broad features of the ecology and energy dynamics of living systems in general terms that transcend any particular taxonomic composition.'[132] Gould, nonetheless, sees some limits to their interpretations and seems to ignore any suggestion that natural selection could be demoted to a secondary force. He seems particularly put off by some of Goodwin's extrapolations from the patterns Gould nonetheless acknowledges there are strong arguments for. Seemingly ignoring the formalist implications of Kauffman's ideas, (as against Darwinian functionalism), for Gould, Kauffman's ideas are strongest in the *origin of life* and in describing *patterns*, rather than the particular species within them, and concludes 'that Kauffman and his colleagues at the Santa Fe Institute for the study of complex systems are groping towards something important,' and that 'the implications for evolutionary theory may extend even further than the major protagonists have recognised.'[133] In this, I am wholly in agreement with Gould, and this volume is an attempt to show in what direction that extension may fruitfully unfold. But these arguments must wait until Chapter 5.

So, to summarise our definitions, Gould encapsulates Darwinian evolution extremely succinctly:

> The basic formulation, or bare bones mechanics [of Darwinian evolutionary theory], is a disarmingly simple argument, based on three

> undeniable facts (overproduction of offspring, variation, and heritability) and one syllogistic inference (natural selection, or the claim that organisms enjoying differential reproductive success will, on average, be those variants that are fortuitously better adapted to changing local environments, and that these variants will then pass their favoured traits to offspring by inheritance).[134]

Armed with these definitions, and an introductory understanding of the field, we may now proceed to Bergson's intervention in the argument around the mechanisms of evolution.

On *Creative Evolution*

In *Creative Evolution*, published in 1907, Bergson sets out in four chapters his own view on the questions of evolution. In a nutshell, he puts forward a version of a structuralist orthogenesis: a combination of functionalist Darwinian natural selection, in second place to a unique formalist/structuralist approach founded on an original impulse (the *élan vital*) and a theory of tendency and divergence driven by that impulse. How these ideas chime with complexity theory I will address in Chapter 5. For now it is important to tease out the essentials of Bergson's own argument, in his own time. To do so I will concentrate on the first two chapters of *Creative Evolution,* which are principally about evolution, leaving the arguments of the latter part of Bergson's book, which are more concerned with consciousness and time, until the first part of Chapter 5.

In the first of Bergson's chapters, following an introduction to his notion of *durée réelle*, he rejects both the 19th century 'radical mechanism' of a Newtonian mechanics-based biology, and the 'radical finalism' of traditional, pre-Darwinian (and orthogenetic) structuralism – and both in terms of how the *durée réelle* makes each nonsensical. He then addresses Darwin and his 'insensible variation,' De Vries and his 'sudden variation,' Eimer and his 'orthogenesis,' and the neo-Lamarckism of his day on the 'hereditability of acquired characters.' I will summarise these arguments first.

For Bergson, the fundamental problem with the Newtonian, clockwork mechanism of most 19th century science is that it has no room for the possibility of any real change or creativity: if effect must always inevitably follow cause, then the effect is somehow pre-ordained, already contained within the cause. Such a universe is in fact predetermined from beginning to end. Such 'radical mechanism' is anathema to Bergson, for whom, as we have seen, consciousness is the locus of indetermination – choice, free will – where change, creativity, and alternatives arise, where that which is not pre-contained in a mechanical cause may transpire: the effect of conscious choice.

By the same token, however, Bergson also criticises – in the same terms, and for the same reasons – the teleological approach of traditional finalism – and all other orthogenetic theories. The notion most popular among such theories derives ultimately from the patriarchal religions, whose Creator God made the world and made Man to put in it. Only barely modified from a seven-day *fiat*, the Creator God, in this revision, sets evolution running in a grand progress from origins up to a pinnacle in the human being. Such teleological progress equally makes genuine creation of the *new* impossible, since, just like mechanism, it rests upon an assumption that the 'whole is given,' from the start. Neither mechanism nor finalism, therefore, can be a satisfactory explanation – for Bergson – of the phenomenon of change, and its inherent properties of indetermination, which for Bergson is the most essential aspect of life.

Darwin gains Bergson's admiration, as well as his criticism. As he says, 'The Darwinian idea of adaptation by automatic elimination of the unadapted is a simple and clear idea.'[135] Nonetheless, Bergson regards it as 'insufficient' to explain 'progressive and, so to say, rectilinear development of complex apparatus,' by dint of its purely negative action. The trouble, for Bergson, with such infinitesimal and random gradualism, is this: 'Why should these causes, entirely accidental, recur the same, and in the same order, at different points of space and time?'[136] It might be suggested, in light of later developments, that cladal relationships exist between such 'disparate points in space and time' that in Bergson's time were not known about, and this is no doubt true. However, the organ Bergson focuses upon – (as the Wolskys point out[137]) – remains, to this day, a conundrum at the heart of his criticism: the eye.

Complex, image-forming eyes have evolved independently dozens of times, in a wide range of different creatures down entirely different cladal lines.[138] Bergson focuses in on two examples: the eye of a vertebrate, and that of molluscs, such as the common Pecten (the large scallop or saltwater clam, which has brilliant blue eyes of complex structure). As he asserts, 'the origin of mollusks may be a debated question, but, whatever opinion we hold, all are agreed that mollusks and vertebrates separated from their common parent-stem long before the appearance of an eye so complex as that of the Pecten. Whence, then, the structural analogy?'[139] Despite arguments regarding the obvious (but minor) differences between the eyes of vertebrates and of the Pecten,[140] the point Bergson makes is that 'the eye of the Pecten presents a retina, a cornea, a lens of cellular structure like our own,' and this remains true, albeit that the optical system it employs is minutely different. As Land's study of Pecten eyes acknowledges, 'structurally, the eye possesses many features typical of the camera eyes of vertebrates.'[141]

This structural analogy is difficult to square with random natural selection. As Bergson relates, 'That two walkers starting from different points and wandering at random should finally meet, is no great wonder. But that, throughout their walk, they should describe two identical curves exactly superposable on each other, is altogether unlikely.'[142] The wholly negative action of adaptation through the survival of some gradual random variations as against others seems incapable of such a complex structural analogy. Even if adaptation is considered positive, as well as negative, in its influence, granting environmental pressure a moulding action sufficient to press evolutionary development toward certain forms, this hypothesis merely assumes a permanent environment: 'The circumstances are not a mold into which life is inserted and whose form life adopts: this is indeed to be fooled by a metaphor. There is no form yet, and the life must create a form for itself, suited to the circumstances which are made for it.'[143] One might suggest that Bergson's thought here foreshadows later understandings of the subtle interplay between *fitness* and *niche,* with regard to the environment. But the point he is driving at is valid regardless of *fitness* or *niche*. As he says, of the ideas current in his time regarding such environmental adaptation, 'such adapting is not *repeating,* but *replying*'[144] and implies active, calculated responses, a finalism that 'goes further than we do – too far, indeed, in our opinion' in the opposite direction of mechanism. This tension between the two meanings of adaptation, which Bergson points out, remains tantalising: 'In any *particular case* one talks as if the process of adaptation were an effort of the organism to build up a machine capable of turning external circumstances to the best possible account: then one speaks of adaptation *in general* as if it were the very impress of circumstances, passively received by an indifferent matter.'[145] Adaptation, in other words, can't at one and the same time be both random mutations selected by survival, and an effort by an organism or species to make the best of its circumstances. The casual use of the word in both senses by evolutionists of his day is something Bergson finds not only intellectually unrigorous but leading to false conclusions.

Bergson subjects the case of the two eyes – that of the vertebrate and that of the Pecten – to the various theories extant in his day. Taking purely accidental variations first, he immediately distinguishes between, on the one hand, the gradualism of Darwin – 'the accumulation of *insensible* variations'[146] and, on the other, the saltationist view of sudden variations put forward by Bateson[147] and De Vries.[148] The latter was very popular at the time Bergson was writing *Creative Evolution* – some decades before the modern synthesis supported Darwinian gradualism over and against saltation. Bergson is impressed with the idea that 'species pass through alternate periods of stability and transformation'[149] in the theories of Bateson and De Vries, but refuses to take sides in the debate between these two kinds of variation, suggesting, instead, that, 'perhaps both are partly true.'[150] Stephen Jay Gould would in fact have enjoyed this assertion, pre-figuring by many decades, as it does, his and Eldridge's now famous 'punctuated equilibrium' theory outlined in their 1972 paper[151] (albeit based upon ideas of Mayr's from 1954[152]), which combines a gradualism so slow as to be characterised as 'stasis,' alongside rare branching speciation too slow to be considered single-generation saltation, but still extremely rapid 'sudden jumps' in terms of geologic time.

For Bergson, however, whether the variations are gradual or sudden, neither is sufficient to explain how both the vertebrate and the Pecten develop complex eyes:

> However the minute structure of the retina may develop, and however complicated it may become, such progress, instead of favoring vision, will probably hinder it if the visual centers do not develop at the same time, as well as several parts of the visual organ itself. If the variations are accidental, how can they ever agree to arise in every part of the organ at the same time, in such a way that the organ will continue to perform its function?[153]

The argument hinges on the notion of 'correlation,' which Darwin himself appealed to, with such 'classic' examples as 'cats with blue eyes are invariably deaf'[154] and 'Hairless dogs have imperfect teeth.'[155] For Bergson this is granted, but – as he has done with the word adaptation – he teases out two meanings of the word 'correlation,' which are used in these arguments. 'A collective whole of *solidary* changes is one thing, a system of *complementary* changes – changes so coordinated as to keep up and even improve the functioning of an organ under more complicated conditions – is another.'[156] Not privy to the later development of genetics, Bergson nonetheless understands the notion, referring to it as the 'germ' that is responsible for later developments. This is the particulate understanding of heredity popularised by De Vries, and his 'pangenes'. He grants that 'the same chemical change of the germ that hinders the formation of hair would probably obstruct that of teeth: it may be for the same sort of reason that white cats with blue eyes are deaf.' [157] These are correlative changes, but of what Bergson describes as the *solidary* kind. With the eye, though, he sees that things are different. He is prepared, even, to grant that 'a change in the germ, which influences the formation of the retina, may affect at the same time also the functioning of the cornea, the iris, the lens, the visual centers, etc.',[158] albeit that these things are probably far more different from one another than hair and teeth. But 'that all these simultaneous changes should occur in such a [*complementary*] way as to improve or even merely maintain vision,'[159] in particular in the circumstances of 'sudden variation,' Bergson will not support.

For Bergson, the two senses of the word correlation – *solidary* and *complementary* – seem to be confused as often as the two senses of 'adaptation.' It seems to Bergson that the one meaning is adopted in the premises of the reasoning while the other is used in the conclusion, such as 'when the principle of correlation is invoked in explanations of *detail* in order to account for complementary variations, and then correlation *in general* is spoken of as if it were any group of variations provoked by any variation of the germ.'[160] Purely mechanistic biology does the same when it makes 'the *passive* adaptation of an inert matter, which submits to the influence of the environment, mean the same as the *active* adaptation of an organism which derives from this influence an advantage it can appropriate.'[161] Now, Bergson admits that Nature may indeed invite this confusion, because it is upon passive adaptations that later mechanisms for active response are then formed. 'Life proceeds by insinuation,'[162] adopting a movement prior to directing it. But, for all that one can technically trace all the increments from a pigment spot to the extraordinary complexity of the finest eye, the mechanism of random variation, for Bergson, is not a sufficient explanation for how such incremental accrual occurred. Thus, Bergson refutes accidental variations, both gradual and sudden, as the sole means by which evolution proceeds.

So, in sum Bergson is happy to accept the reality of Darwin's natural selection mechanism, but challenges: the *agency,* by which only variation at the level of the organism is involved; the *efficacy,* by which the processes of natural selection are sufficient, in themselves, for evolution to proceed; and, indeed, the *scope,* by which Darwin claims everything, everywhere, for all time has been determined by such accidental variation. However, unlike Gould, who continues to accept the essential thrust of Darwin's solution, for Bergson there are more fundamental problems. Firstly, in the way the notion of adaptation is used, in these arguments, in two different senses: the one in setting up an argument, the other in its conclusion. Secondly, by the same token, the notion of correlation, by which the action of a 'germ' (prior to the development of genetics) might be discerned, is similarly used in two different ways: *solidary* and *complementary,* the one for the detail, the other in general. In these ways, arguments which state that adaptation *alone* is capable of producing the extraordinary complexity of life are shown to have logical flaws: life is deemed both the passive receiver of environmental imprint and the active exploiter of advantage, at one and the same time. For the mechanist, of course, the 'active exploiter' is a blind automaton, in a predetermined universe, merely the effect of cause. For the finalist, the 'active exploiter' was always destined to take its path.

For Bergson, life is consciousness, choice, free will: the 'active exploiter' cannot be solely a 'passive receiver' at the same time – albeit that activity might make use of receptiveness as an insinuative ploy in its strategy. As he lays out in the second chapter of *Creative Evolution,* which I shall come to presently, Bergson's understanding of such consciousness is implicit in mobility, and thus present in the most rudimentary form of animal life. Although such consciousness comes in two forms – instinct and intellect – and animal life has access only to instinct, it nonetheless coheres around the notion of choice. Instinctive choice is still choice: organisms must therefore be regarded as capable of trying to make the best of their circumstances when they make such choices – they are active exploiters. This is the form of adaptation that implies, for the finalists, the striving of organisms along a predetermined path, but which, for the mechanists, should not really exist, albeit that they use such language in their descriptions nonetheless, hiding this meaning of the word adaptation under the guise of 'insensible variation', as if the organism were simply inert matter. The 'active exploiter,' in other words, for Bergson, is not a blind automaton, nor is it destined to take any path. The 'active exploiter' makes choices.

Bergson then turns his attention to the orthogenesis of Eimer. Eimer coined the term orthogenesis, and tried, in his evolutionary theory, to combine progress with functionalist determination. For Gould this functionalism, however, was ultimately that of Lamarck, rather than of Darwin, and rejected natural selection. For Bergson, Eimer has clearly worked hard to demonstrate that evolutionary change 'is brought about by the influence of the external on the internal, continuously exerted in the same direction, and not, as Darwin held, by accidental variations.'[163] But, as Bergson lucidly points out, Eimer's insistence that this process is mechanistic would suggest that, say, the mechanical influence of light would have created the eye of both the vertebrate and the mollusc. This would be to suggest that, despite the fact that 'the organic substance [embryo] which evolved toward the first of these two forms could not have been identical with that of the substance which went in the other direction,' somehow 'under the influence of light, the same organ has been constructed in the one case as in the other'[164] A mechanistic answer from external influence again fails to explain how the structural analogy between the two example eyes can be possible. Yet this is not to deny the fact that, nonetheless, 'Every moment, right before our eyes, nature arrives at identical results, in sometimes neighbouring species, by entirely different embryonic processes.'[165]

Satisfied, then, that he has dispensed with both Darwinian and saltational adaptation from accidental variations, and with Eimer's orthogenesis, as sufficient explanations of the similarity of vertebrate and mollusc eyes, Bergson at last turns to the most thoroughly structuralist of the evolutionary theories: those of, and inspired by, Lamarck. Lamarck (1744–1829) was one of the first proponents of the idea of evolution, a generation or more before Darwin, and one of the first to suggest that it occurred according to natural laws. His evolutionary theory, however, was fundamentally structuralist – envisaging a grand progress toward the current reality – and included a theory of the inheritance of acquired characteristics. As Bergson summarises, for Lamarckians, 'The variation that results in a new species is not, they believe, merely an accidental variation inherent in the germ itself, nor is it governed by a determinism *sui generis* which develops definite characters in a definite direction, apart from every consideration of its utility. It springs from the very effort of the living being to adapt itself to the circumstances of its existence.'[166] Such an approach can (but does not always) include an internal and psychological principle of development, which intrigues Bergson. Indeed, it seems to him the only approach, thus far, capable of accounting 'for the building up of identical complex organs on independent lines of development.'[167] But the neo-Lamarckian theories around in Bergson's day use the term 'effort' without, seemingly, appreciating that it ought to be taken in a much deeper sense than they suppose. To do so, of course, raises serious questions. How, for example, does such an effort produce so complex an organ as an eye? How, indeed, does a plant exert effort?

Bergson first of all refuses to join the debate – let alone take sides – around the 'transmissibility of acquired characters,' – the saltation which above all caused Lamarckism's downfall at the onset of the Modern Synthesis. As we have seen, with Gould, a slightly slower form of saltation – not involving acquired characteristics as such, but rapid, sudden jumps in variation/selection-based evolutionary change, interspersed with long periods of stasis – has indeed, since, itself caused the downfall of Darwin's gradualism, which had been adopted by the Modern Synthesis in place of saltation. Bergson is clearly wise not to have engaged too deeply in this debate, perhaps seeing that the then current state of biological science was still too nascent for a true answer to emerge. Nonetheless, in principle he spends a few pages expressing a suspicion of the transmissibility of acquired *characters,* suggesting that instead, perhaps, the transmissibility of acquired *deviations* from the form that would otherwise have taken shape might be possible, but that *deviations* and *characters* are not the same thing. If, then, hereditary transmission is – at best – the exception and not the rule, how, 'shall we expect it to develop an organ such as the eye?'[168]

So, in his first chapter of *Creative Evolution*, Bergson has 'tried on' for evolution 'the two ready-made garments at our disposal, mechanism and finality'[169] and found both wanting. He has submitted all the various forms of evolutionism current in his day to his focus upon the structural analogy of the eyes of both vertebrates and molluscs, and found each wanting. He is keen to add the caveat, nonetheless, that 'each of them, being supported by a considerable number of facts, must be true in its way. Each of them must correspond to a certain aspect of the process of evolution.'[170] But he suggests that an overview of them all can be the task of philosophy, and 'that one of them might be recut and resewn, and in this new form fit less badly than the other;'[171] a kind of structuralism/formalism without the finality, that both includes the functional adaptationism of Darwin as a secondary moulder, but also allies itself to consciousness.

He sides with the idea that 'the essential causes of variation are the differences inherent in the germ borne by the individual, and not the experiences or behaviour of the individual in the course of his career,' but not that 'the differences inherent in the germ [are] purely accidental and individual.' This is the key point where Bergson's evolutionism displays its structuralism: 'We cannot help believing that these differences are the development of an impulsion which passes from germ to germ across individuals, that they are therefore not pure accidents, and that they might well appear at the same time, in the same form, in all the representatives of the same species, or at least in a certain number of them.'[172] He cites De Vries' mutation theory here, as an example amongst then contemporary evolutionary theories that are 'modifying Darwinism profoundly on this point.'[173] We might, today, cite rather the 'punctuated equilibrium' theory of Eldridge and Gould, that likewise, and better, 'asserts that at a given moment,' as Bergson describes it, 'after a long period, the entire species is beset with a tendency to change.'[174]

It is this *tendency to change* that will form a core part of Bergson's evolutionism, as it unfolds through the rest of his book. As he describes it:

> The *tendency to change,* therefore, is not accidental. True, the change itself would be accidental, since the mutation works, according to De Vries, in different directions in the different representatives of the species.[175]

Substitute De Vries for Gould, and we have an evolutionism of which Darwinian accidental variation and natural selection remain the *detail,* but in which Darwinian gradualism is replaced with the 'sudden jumps', not of De Vries' mutation theory, but of Gould's 'punctuated equilibrium': jumps which, for Bergson, are governed by a *tendency* – the structural element, of which Gould fights shy. It is the nature of this *tendency* which lies at the heart of Bergson's evolutionism, and which in Chapter 5 we will see may be interpreted – in the same spirit as we just substituted Gould for De Vries – in light of the recent revelations of complexity theory.

As I have made clear, then, this book does not try to suggest that 'Bergson was right all along.' There has indeed been a great range of developments in science since his day far beyond what he had at his disposal. Nonetheless, *in principle,* Bergson's thought leads – as above – all too often in very fruitful directions which have since been proven, if not prescient, then certainly extremely insightful considering the state of the advance of biological science in his time. It is in this spirit that his evolutionism, and that of the evolutionary biologists influenced by complexity theory, converge, as we shall explore in Chapter 5.

It is, perhaps, unfair to characterise Bergson's evolutionism as a form of orthogenesis, given such fundamental criticism in this first chapter of *Creative Evolution* of all other orthogenetic ideas. Yet Bergson admits he arrives at a hypothesis like Eimer's, 'according to which the variations of different characters continue from generation to generation in definite directions.'[176] But for Bergson Eimer's attempt to use only physical and chemical causes as explanation falls short. In the example of the eyes, 'if there is orthogenesis here, a psychological cause intervenes.' But such a psychological cause has to be more than the mere effort of the individual, which can only operate in a minority of cases, and only by *deviation* in the animal, and never in the vegetable kingdom.

So, contrary to Darwin's assertion that natural selection is both the primary and exclusive driver of evolution, from time immemorial to the present day, across all of life – the ultimate functionalist approach – Bergson asserted, not a Lamarckian, or Eimerian, or Batesonian, but a nonetheless structural primary force to which natural selection – which he acknowledged and praised as a reality – nonetheless plays second fiddle. This primary force, this *tendency,* he names the *élan vital* (variously translated as 'vital impulse', 'vital impetus,' 'vital force,' 'creative impulse' or 'living energy'), which he argues lies at the heart of evolution, all initiated by:

> an *original impetus [élan originel]* of life, passing from one generation of germs to the following generation of germs through the developed organisms which bridge the interval between generations. This impetus, sustained right along the lines of evolution among which it gets divided, is the fundamental cause of variations, at least of those that are regularly passed on, that accumulate and create new species.[177]

For Bergson, then, we must get beyond both mechanism and finalism, which are, 'at bottom, only standpoints to which the human mind has been led by considering the work of man' – mechanism based on our ability to create machines, finalism upon our belief in destiny. How to get beyond them? Considering the eyes at the focus of his argument, Bergson suggests the answer to this conundrum lies in the 'contrast between the infinite complexity of the organ and the extreme simplicity of the function.'[178]

Here then, one of Bergson's characteristic methods comes into play – conceiving of the subject at hand in terms of mobility and of flow, rather than in terms of fixed objects abstracted out of time into an imaginary stasis. Reprising arguments concerning movement from *Matter and Memory*, concerning the distinction between movement and trajectory, Bergson suggests that the mechanistic evolutionary theories see only the positions, the various points along the trajectory, and that the finalist approach would take only the order in which they appeared into account. Both would actually miss the movement – which is reality itself. The movement is both more than the positions and more than the order in which they appear. But also less: 'for, to arrange points in a certain order, it is necessary first to conceive the order and then to realize it with points; there must be the work of assemblage and there must be intelligence, whereas the simple movement of the hand contains nothing of either.'[179]

Applied to the example of the vertebrate and mollusc eyes, Bergson thus argues that, whilst there is more to vision than just the component cells of the eye and their mutual coordination, there is also nowhere near the 'most formidable of the labors of Hercules' attributed to Nature by both mechanism and finalism in making it possible: 'Nature has had no more trouble in making an eye than I have in lifting my hand,' says Bergson.[180] Paradoxical as it may seem, this ease is in fact what complexity theory grants to evolutionary biology as well, as we shall see in our discussion of phase transitions in Chapter 5. Bergson explains to us that the reason we find it paradoxical is our habit of seeing organisation in terms of manufacturing, which, as he points out, is peculiar to man, alone. 'To manufacture, therefore, is to work from the periphery to the center, or, as the philosophers say, from the many to the one. Organisation, on the contrary, works from the center to the periphery.' More profoundly, a manufactured thing contains only what has been put into it. An organised thing, albeit that science will only discover how it might be manufactured, will display something else: the invisible imprint or implication of the original impetus. But,

> if now we are asked why and how it is implied therein, we reply that life is, more than anything else, a tendency to act on inert matter. The direction of this action is not predetermined; hence the unforeseeable variety of forms which life, in evolving, sows along its path. But this action always presents, to some extent, the character of contingency; it implies at least a rudiment of choice. Now a choice involves the anticipatory idea of several possible actions. Possibilities of action must therefore be marked out for the living being before the action itself.[181]

Visual perception, as Bergson showed in *Matter and Memory,* is nothing else, and the visible outlines of objects, 'the design of our eventual action on them.' Vision, then, is bound to be discovered in all animals, 'and it will appear in the same complexity of structure wherever it has reached the same degree of intensity.'[182] This is possible, because, in fact, despite the divergent tendency of evolution to produce variety, the similarities that are at the same time observable should be considered not as analogies, but as aspects of nature that are 'mutually complementary.'[183] Action, choice, consciousness – these are presented as essential to life, in the context of movement, and thereby to evolution. The complex eye is not only easy for Nature to have manifested, it is inevitable, and a core element of how consciousness – life – becomes a centre of action.

A universe on the model of consciousness

Bergson's task then, in the succeeding chapters of *Creative Evolution*, is to trace out these notions of *tendency* and *divergence,* the workings of the *élan vital,* and how these notions and the phenomenon of consciousness are interrelated. In this way, he sets out to tell the story, in his second chapter, of the relationship between the evolution of life and the evolution of consciousness, by which 'The intellect is thus brought back to its generating cause.'[184] He does so by distinguishing first between vegetable and animal life, and then between instinct and intelligence.

It is important to restate, that Bergson at no point suggests that the *élan vital* is in any sense some kind of vitalism. He is explicit in stating that this *élan vital* is a force whose existence cannot be scientifically verified – a crucial distinction from the traditional 'substantival' vitalists, who contended that there must be some fluid or other organic material at the spring of life. Some of these vitalists also believed that there must be some divine force outside of matter. The *élan vital*, however, is a property of matter itself, consistent with the reconception of the material inherent in the concept of the *durée réelle*. The *élan vital* is a tendency, with no divine predetermination, but which nonetheless continually pushes evolution in certain, key directions.

He begins his second chapter with one of the most memorable images of the *élan vital,* likening its action to that of an exploding shell:

> When a shell bursts, the particular way it breaks is explained both by the explosive force of the powder it contains and by the resistance of the metal. So of the way life breaks into individuals and species. It depends, we think, on two series of causes: the resistance life meets from inert matter, and the explosive force – due to an unstable balance of tendencies – which life bears within itself. The resistance within inert matter was the obstacle that had first to be overcome. Life seems to have succeeded in this by dint of humility, by making itself very small and very insinuating, bending to physical and chemical forces, consenting even to go a part of the way with them, like the switch that adopts for a while the direction of the rails it is endeavouring to leave. Of phenomena in the simplest forms of life it is hard to say whether they are still physical and chemical or whether they are already vital.[185]

Bergson describes the action of the *élan vital* as a tendency that creates a 'sheaf' of divergence, bifurcating along a host of different and varied lines. His vision of cladistics, therefore, is of an original impetus exploding down lines of ancestry, like the fractal tendrils of an encroaching frost or the growing leaves of a giant fern. He is quite clear that there have been many 'blind alleys' and that there are survivors amongst the great panoply of living things of many different lines of divergent development, but also that there are two or three principal 'highways,' one of which, the vertebrates, happens to lead up all the way to 'man.'[186] Between these highways, 'run a crowd of minor paths in which ... deviations, arrests, and set-backs, are multiplied.'[187]

But one of the most significant aspects of the *élan vital*, for Bergson, for all its challenge to the mechanistic negativity of the failure of the unadapted, is its absolute lack, on the other hand, of any teleology, in the manner of the finalists' approach to evolution. For Bergson there is no 'particular impulse towards social life',[188] for example, and it has appeared in different forms: amongst the ants and bees on the one hand, as well as amongst humans, on the other – each form accentuating either equilibrium, in the first case, or progress, in the second, whereas a combination of the two might have been the best of all worlds.[189]

'That adaptation to environment,' Bergson says, 'is the necessary condition of evolution we do not question for a moment.' It is obvious, 'that a species would disappear, should it fail to bend to the conditions of existence which are imposed on it.' Nonetheless, 'it is one thing to recognise that outer circumstances are forces evolution must reckon with, another to claim that they are the directing causes of evolution.'[190] Indeed, the mechanistic, adaptationist argument would actually more likely have ended up with either no life, or very little diversity at all. 'A mere glance at fossil species shows us that life need not have evolved at all, or might have evolved only in very restricted limits ... Certain Foraminifera have not varied since the Silurian epoch. Unmoved witnesses of the innumerable revolutions that have upheaved our planet, the Lingulae are today what they were at the remotest times of the Palaeozoic era.'[191]

Without some original impetus, then, the role of natural selection seems insufficient, on its own, to explain the present diversity. 'The truth is that adaptation explains the sinuosities of the movement of evolution, but not its general direction, still less the movement itself.'[192] This general direction, moreover, should not be interpreted as any kind of pre-ordained progress. There is, in fact, nothing so integrated and coherent about the great variety of life. But a direction is there, nonetheless, which Bergson describes as 'centres around which the incoherence crystallises,'[193] as if there were some kind of magnetic attraction to the tendency, some property of the process of divergence that meant that the multiple forms of life as they are continually invented cluster around certain forms, rather than others, or none. This attraction is a key point we shall return to in Chapter 5.

In his characteristic method of making distinctions, it is through examining the difference between the vegetable and the animal that Bergson is able to pinpoint what I alluded to earlier: the connection between mobility and consciousness. Characterising the taxonomic clustering and distinction around these two 'kingdoms' as a 'grouping' of life forms, in which there are animal-like characteristics to be found in certain flora, and the boundary between the two is particularly blurred amongst certain tiny fauna, he offers the proposition: '*The group must not be defined by the possession of certain characters, but by its tendency to emphasise them.'* Discussing various carnivorous plants, and of course fungi, Bergson stresses that static specific differences cannot be identified, but rather that it is dynamic differences and tendencies that enable us to distinguish between these groups. Fungi, for example, have not evolved beyond their level, but represent a blind alley of the vegetable kingdom. Broadly then, one can distinguish in the following manner: 'We may say that vegetables are distinguished from animals by their power of creating organic matter out of mineral elements which they draw directly from the air and earth and water.'[194] But because in order to get nourishment by eating vegetables animals have to move in order to get hold of them, 'Animal life is characterised, in its general direction, by mobility in space.'[195] Now Bergson offers plenty of caveats for this, as with all his arguments, but is happy to conclude, nonetheless, that 'although both mobility and fixity exist in the vegetable as in the animal world, the balance is clearly in favour of fixity in the one case and mobility in the other.'[196]

This distinction – for all its caveats – between fixity and mobility, is where the role of consciousness enters Bergson's argument. There is an obvious relationship: 'The more the nervous system develops the more numerous and more precise become the movements among which it can choose; the clearer, also, is the consciousness that accompanies them.'[197] But a nervous system is not an absolute requirement for consciousness. The most rudimentary animal forms lack much in the way of nerve centres, just as they do of other more advanced and complex characteristics; yet, as Bergson suggests, 'it would be as absurd to refuse consciousness to an animal because it has no brain as to declare it incapable of nourishing itself because it has no stomach.'[198] It is not the biological mechanisms of nerves and ganglia wherein consciousness resides. In another of the propositions Bergson introduces in this chapter, along with a host of relevant caveats, he concludes that, 'the humblest organism is conscious in proportion to its power to move *freely*.'[199]

Having thus distinguished between flora and fauna by dint of fixity and mobility, and associated mobility with consciousness, Bergson is ready to return to his opening image of the exploding shell: for the vegetable, ultimately, is the battery storage for the energy of the sun, and the animal, sourcing that energy from its vegetable food (or by eating other animals who have eaten vegetable food) converts this energy into motion. Photosynthesis, in other words, and eating the photosynthesisers, turns light, ultimately, into movement. Nor is this an easy task. A great deal of energy – in proportion to the size and complexity of the organism – is expended in merely standing still. 'No doubt, every living cell expends energy without ceasing, in order to maintain its equilibrium,'[200] says Bergson, and 'every animal cell expends a good deal – often the whole – of the energy at its disposal in keeping itself alive.'[201] But the ultimate purpose of the harvesting and storing of energy is to enable movement.

Summing up the arguments so far, then, Bergson reminds us that, 'The role of life is to insert some *indetermination* into matter. Indeterminate, that is unforeseeable, are the forms it creates in the course of its evolution. More and more indeterminate also, more and more free, is the activity to which these forms serve as the vehicle.'[202] The vegetable excels at the gathering and storing of energy, but sacrificed its own potential to move in order to achieve it. The animal preys upon the vegetable, unable to gather energy itself, but needing movement in order to gather its prey. Thus the nervous system, in all its complexity, becomes 'a veritable *reservoir of indetermination*. That the main energy of the vital impulse [*élan vital*] has been spent in creating apparatus of this kind is, we believe, what a glance over the organised world as a whole easily shows.'[203] Bergson is not ascribing any great overarching power to the *élan vital* here – indeed he is keen to point out this force 'is always seeking to transcend itself and always remains inadequate to the work it would fain produce.'[204] The *élan vital* in evolution he likens to the effort of conscious freedom in the human self. We are all, always constrained by myriad contingencies over which we have little if any control, and the moments of true freedom, when we are able to make truly impactful choices, are inevitably rare. So, too, with the *élan vital:* 'Even in its most perfect works, though it seems to have triumphed over external resistances and also over its own, it is at the mercy of the materiality which it has had to assume.'[205]

Here, then, with consciousness linked to mobility, Bergson introduces another distinction – that, within consciousness, between instinct and intellect. All too often natural philosophers have suggested a linear relationship from the vegetable, through the animal, through the instinctive – with the intellectual at the top of the tree. For Bergson there is no such tree. In fact all these are different lines from the original impetus, different highways of the sheaf of divergence. The energy-absorbing fixity of the vegetable kingdom, the mobility of the animal kingdom by which it captures the energy stored by the vegetable, the consciousness implied by that mobility and its two different forms, are, in the end, differences in kind rather than degree: '*they are three divergent directions of an activity that has split up as it grew.*'[206]

This point Bergson drives home for the rest of this second chapter. Intelligence and instinct, like all things in the kernel of the sheaf, were originally all but indistinguishable, and still 'retain something of their common origin. Neither is ever found in a pure state.'[207] But different, nonetheless, they do become, and the distinction between them is not, as one might surmise, the fact of tool use: all too often, as Bergson points out, the apes and elephants in particular, have been shown to be adept at the use of tools. It is in the *manufacture* of tools, in invention, that the intellect distinguishes itself from instinct. For Bergson, this is what makes the human race above the rest: 'we should say not *Homo sapiens*, but *Homo faber*. In short, *intelligence, considered in what seems to be its original feature, is the faculty of manufacturing artificial objects, especially tools to make tools, and of indefinitely varying the manufacture.'*[208] The ultimate manufacture, being, of course, thought alone; for, while instinct and intelligence both involve knowledge, 'this knowledge is rather *acted* and unconscious in the case of instinct, *thought* and conscious in the case of intelligence.'[209] Thus, intelligence is something concerned rather with *form,* and instinct rather with *matter,* and therefore, in the human, the one really cannot do without the other: '*There are things that intelligence alone is able to seek, but which, by itself, it will never find. These things instinct alone could find; but it will never seek them.*'[210]

Here, then, Bergson offers us seven defining features of human intelligence:

1. *Our intelligence, as it leaves the hands of nature, has for its chief object the unorganised solid.*[211]
2. *Of the discontinuous alone does the intellect form a clear idea.*[212]
3. *Of immobility alone does the intellect form a clearer idea.*[213]

4. *The intellect is characterised by the unlimited power of decomposing according to any law and of recomposing into any system.*[214]
5. What characterises the signs of human language is not so much their generality as their mobility. *The instinctive sign is* adherent, *the intelligent sign is* mobile.[215]
6. Intelligence, even when it no longer operates upon its object, follows habits it has contracted in that operation: it applies forms that are indeed those of unorganised matter.[216]
7. *The intellect is characterised by a natural inability to comprehend life.* [217]

I shall spend a short time unpacking some of these propositions, but taking them rather as a whole than one by one. What Bergson is getting at is a description of intelligence as an aspect of consciousness – instinct being another – that is focussed outward, upon matter, upon the inert, upon the fixed, because it is only thus that it can be of use to us. As we have seen when considering the ideas of the *durée réelle* and of matter and perception, the physical, objective reality that we perceive is in fact a property of our perception, fixing what is in fact mobile, apportioning the outlines of solidity to that which is in fact integral to the undivided flow of the universe of which we too are a part. In short, we see objects – and we see fixed objects – and we apportion to them, signs: the constituents of language. But these signs are not fixed any more than the objects, indeed language cannot be rooted to objects it refers to – the 'referent' – if it is able to be used internally, beyond instinct, for intellectual ideas. But because words are made initially for things, when they are used to designate ideas they treat them as things: fixed, solid, immobile.[218] Because of this natural bent of intelligence to see fixed objects and treat ideas as of a similar ilk, we are ultimately at a disadvantage when it comes to understanding what evolution is actually about. 'Just as we separate in space, we fix in time. The intellect is not made to think evolution, in the proper sense of the word– that is to say, the continuity of a change that is pure mobility.'[219] Thus, in the end, life is something that the intellect is not designed to comprehend.

Here, then, the *intuition philosophique* must be called upon, if we are to apprehend the true meaning of evolution. Intuition, in this context, is 'instinct that has become disinterested, self-conscious, capable of reflecting upon its object and of enlarging it indefinitely. That an effort of this kind is not impossible, is proved by the existence in man of an aesthetic faculty along with normal perception.'[220] Intuition, one might also say, from the opposite perspective, when shrunk down within the confines of an organism spending all its energy just maintaining itself, is instinct. In this manner, certain flying insects know precisely where to sting their victim to paralyse rather than kill in order to lay their eggs in it so that when the larvae hatch they have fresh meat. To suggest that they tried all sorts of different nerve centres until they got the right one is to impute too much intelligence to insects, and even to suggest the heritability of acquired characteristics. But seen through the eyes of instinct as a shrunken intuition both the wasp and its caterpillar host are merely activities, and the action centre where paralysis may be induced in the caterpillar by the wasp's pinpoint sting is reached instinctively, intuitively, without need of thought or eons of phylogenetic trial and error.

Life, in summary then, is consciousness itself, impacting upon matter, either sleepy – in plants – or wakeful – in moving organisms; and there either as instinct or as intelligence. Human life, in particular, is special because of the peculiar nature of intelligence. Intuition alone gets shrunk into instinct. Intellect, focused outward onto matter, has a potentially unbounded horizon, and can even turn back in on itself to free up the potential possibilities of the intuition which remains within. Here, Bergson reveals his belief – not by dint of any finalistic plan – in human exceptionalism, as I shall explore more in my final chapter: 'Between [man] and the animals the difference is no longer one of degree, but of kind.'[221] Not only is consciousness, in other words, the 'motive principle of evolution', but among all the various mobile organisms, all the conscious beings, 'man comes to occupy a privileged place.'[222] Manufacture, and invention, have indeed become key: the animal is focused entirely on those tasks necessary for its well-being, the human is focused on automating those tasks, in order to free its consciousness to contemplate other things.

We may suggest then, at this point, another variation upon our table of Bergsonian distinctions: Table 2.3 Life.

The third and fourth chapters of *Creative Evolution* I will deal with much more briefly, now, and return to in Chapter 3, through Deleuze's eyes, and in Chapter 5, in the context of how quantum theory offers physical

Table 2.3 Life

<table>
<tr><td rowspan="2">LIFE</td><td>conscious</td><td>movement</td><td>animal</td><td>relations, form</td><td rowspan="2">MAN</td><td>Intuition
intelligence
instinct</td></tr>
<tr><td>insensible</td><td>fixity</td><td>vegetable</td><td>things, matter</td><td></td></tr>
</table>

substantiation of Bergson's ideas. In this latter half of his book, Bergson addresses the very nature of existence, wherein consciousness becomes the key feature above and beyond mere matter. He outlines the features of a panpsychic universe he sees our consciousness inhabiting – indeed, paints our individualities as but windows upon the universal consciousness through which matter is conjured and experienced. Bergson quotes from the work of the physicist Ludwig Boltzmann, in *Creative Evolution,* and it seems he may have been conversant already with Planck's work, although he makes no mention of him, when he describes a universe of action and interaction, rather than fixed matter:

> The more physics advances, the more it effaces the individuality of bodies and even of the particles into which the scientific imagination began by decomposing them: bodies and corpuscles tend to dissolve into a universal interaction. Our perceptions give us the plan of our eventual action on things much more than that of things themselves. The outlines we find in objects simply mark what we can attain and modify in them. The lines we see traced through matter are just the parts on which we are called to move.[223]

Thus, materiality – the concrete made from the vibration/energy – is a view of the mind that is getting ready to act, set in a 'space' set up by the mind. The consciousness of animals is the same, of course, with the same instinct as humans, just more of it, and with the same intelligence as humans, just less of it. But the quantity of intelligence in the human progressively changes how consciousness perceives reality: '*The more consciousness is intellectualised, the more is matter spatialised.*'[224]

Ultimately, the whole canon of Greek thought, not just the Eleatics, but Plato and everything that has followed, founders on this very point: the difficulty of going beyond intelligence to the Whole beyond our intelligence. For Bergson it can only be achieved by a leap. No amount of walking will teach us to swim, though once we have dived in we will find that swimming is not that far different from walking. Bergson offers, indeed, what seems at times a heartfelt defence of philosophy, at the same time as a plea for it to address what he sees as the real issues of existence, not those dictated to it by positive science. Positive science, after all, sees only the inert in life. Philosophy that demarcates between the inert and the living will enable science, the theory of knowledge, and metaphysics, to all profit from the meeting. He is emphatic that we must appreciate that consciousness contains the intellect, and not the other way round.

This argument leads him into a direct refutation of the position taken by Kant, in his Transcendental Aesthetic, which posits only three options: mind is determined by matter, matter is determined by mind, or there is some mysterious agreement between them. For Bergson the answer is simply 'none of the above.' He offers, instead, a fourth option: that they have, in fact, evolved together. 'Intellect and matter have progressively adapted themselves one to the other in order to attain at last a common form,' he tells us, stressing that '*This adaptation has, moreover, been brought about quite naturally, because it is the same inversion of the same movement which creates at once the intellectuality of mind and the materiality of things*.'[225] Indeed, if reality is an undivided whole, then conceiving it spatially, and dividing it up into tiny little constituent parts – as is the habit of the intellect – is bound to reveal a plethora of neat mathematical interrelations that hold them all together – which is precisely what we find.

He describes the principle of thermodynamics as 'the most metaphysical of the laws of physics' because without a host of mathematical symbols it simply points out 'the direction in which the world is going … [that all] will gradually give way to the relative stability of elementary vibrations continually and perpetually repeated.'[226] Running counter to this entropy, of course, is the force of the *élan vital*: 'All our analyses show us, in life, an effort to remount the incline that matter descends.'[227] Thus, with the two forces of entropy and the *élan vital* running in opposite directions, it is clear for Bergson that, 'There are no things, there are only actions.'[228]

Bergson offers, at this point, perhaps the clearest definition of what he means by the *élan vital* in the whole book:

> All life, animal and vegetable, seems in its essence like an effort to accumulate energy and then to let it flow into flexible channels, changeable in shape, at the end of which it will accomplish infinitely varied kinds of work. This is what the *vital impetus* [*élan vital*], passing through matter, would fain do all at once. It would succeed, no doubt, if its power were unlimited, or if some reinforcement could come to it from without. But the impetus is finite, and it has been given once for all. It cannot overcome all obstacles. The movement it starts is sometimes turned aside, sometimes divided, always opposed; and the evolution of the organised world is the unrolling of this conflict.[229]

Thereafter, in an extraordinary argument in his final chapter around the ideas of Zeno, Plato, Aristotle, Leibniz, Spinoza, Kant and Spencer, which he calls a 'history of systems,' he outlines how the whole of Western Philosophy has founded itself upon two misapprehensions, or illusions. The first illusion 'consists in supposing that we can think the unstable by means of the stable, the moving by means of the immobile.'[230] The second illusion posits that 'Just as we passed through the immobile to go to the moving, so we make use of the void in order to think the full.' It is due, no doubt, to this foundational philosophical argument around the concept of negation, that Bergson was described by pragmatist philosopher William James as having 'killed intellectualism definitively and without hope of recovery. I don't see how it can ever revive again in its ancient Platonising role of claiming to be the most authentic, intimate, and exhaustive definer of the nature of reality.'[231] It is the cinematographical – sliced up snapshots of duration, so typical of the intellect's approach – which indeed is made to see fixed matter, that confounds our perception, and draws these illusions over our intuitive senses; which, only with an effort of will – turning the intellect back upon itself, as it were, no longer outward-facing but inward looking – might apprehend a glimpse of true duration.

For Bergson the nature of distinct consciousness, the intellect, is to look back, as well as out. But to see the principal, the greater consciousness, we must look forward, and again we can only do so as an act of will – difficult and temporary – and even then only our own individual fragment. To get to the 'principle of all life' one must go even further still. For the self – the one in the many – is only so when viewed through the intellectual lens that divides the whole. The 'many-ness' of that whole, indeed, only exists when it comes into contact with matter. 'I am then (we must adopt the language of the understanding, since only the understanding has language) a unity that is multiple and a multiplicity that is one.'[232]

In sum, when Bergson describes the *élan vital* as a property of matter itself, he is also saying that matter, as we perceive it, is in fact how the *élan vital* expresses itself – represents itself back to itself. Bergson's *élan vital* is a force climbing in the opposite direction to entropy, and the role of instinct in speciation – how the wasp knows where to sting its prey – a clear example of *emergence* in the evolution of new species: a term we will return to in Chapter 5. His evolutionism is in keeping with Gould's 'punctuated equilibrium', for all that Gould did not acknowledge it, and focuses on the complex nature of the eye, which remains to this day a hotly debated conundrum in evolutionary biology. His conception of matter as activity, as we will see in Chapter 5, chimes well with the ideas of quantum mechanics. Moreover, the argument of this present volume is that Bergson's ideas closely presage what the complexity sciences have discovered as a result of late 20th century computing power unavailable to the science of the late 19th – namely *explosively emergent self-organisation*. More than this, however, the role of consciousness in evolution – in existence itself – is something that the complexity sciences and evolutionary biologists making use of them can no longer ignore. I shall address these arguments in more detail in Chapter 5.

Firstly, in Chapter 3, it is important to ask why Bergson's ideas, so lauded at the time, fell so completely from favour, and how, in recent years, they have been rediscovered. I then attempt, in Chapter 4 of this volume, to extend Bergson's history of systems: not in the philosophical vein that Bergson undertook, with the philosophers and philosophies mentioned above, nor concerned with the antiquity he addressed; but a history of systems *since* Bergson, undertaken through the method of poststructuralist genealogy; a method (arguably) derived from Bergson. Through this history of the evolution of modern systems thinking, we will find how the structuralist/formalist approach, and the multiple, mobile form of such structuralism peculiar to the *élan vital,* known as 'poststructuralism' since the 1960s, have both characterised the sciences of the 20th century, and led, ultimately, to the complexity sciences that will be the focus of Chapter 5.

Notes

1. Kolakowski, Deleuze and others have asserted the same – see Kolakowski, L (1985) *Bergson* South Bend, IN: St Augustine's Press p3; also Deleuze, G. (1991[1966]) *Bergsonism*. Translated by Hugh Tomlinson and Barbera Habberjam. New York: Zone Books p. 9
2. Famously attributed to Derrida and *Of Grammatology* – and certainly more foregrounded and more fully developed in Derrida's work. I believe, nonetheless, that one could attribute the roots of the method of deconstruction to Bergson, and have therefore used the term to describe how Bergson undertakes many of his critiques of opposing debates.
3. Georg Ernst Stahl (1660–1734) proposed a theory of animism and Hans Driesch (1867–1941) a theory of entelechy, both of which opposed the discoveries of the physical sciences with alternative theories.
4. *CE* p. xxiv
5. *CE* p. xxiv
6. 'Introduction Part II Stating the Problems', in *CM* p. 35
7. H. Wildon Carr (1919) *Henri Bergson: the philosophy of change* London: T. Nelson and Sons, available from the Internet Archive https://ia600305.us.archive.org/11/items/henribergsonphil00carruoft/henribergsonphil00carruoft.pdf p. 14
8. Adamson, G.D. 2000. Science and Philosophy: Two Sides of the Absolute. *Pli* (9), 54.

9. *TFW* pp. 23–29
10. *MM* pp. 156–157
11. *MM* p. 17
12. *CE* p. 87
13. *CE* p. 94
14. Deleuze, G. (1991[1966]) *Bergsonism*. Translated by Hugh Tomlinson and Barbera Habberjam. New York: Zone Books p. 7
15. Torretti, R, (1999) *The Philosophy of Physics* Cambridge: Cambridge University Press pp. 242–243.
16. Duhem (1914[1906]) *The Aim and Structure of Physical Theory* p. 24, as quoted in Torretti, R, (1999) *The Philosophy of Physics* Cambridge: Cambridge University Press pp. 242–243.
17. *MM* pp. 156–157
18. *TFW* pp. 129–139
19. 'Introduction Part II Stating the Problems', in *CM* p. 33
20. Deleuze, G. (1991[1966]) *Bergsonism*. Translated by Hugh Tomlinson and Barbera Habberjam. New York: Zone Books p. 13
21. *IM* in *CM* pp. 206–207
22. *IM* in *CM* pp. 187–237
23. Bergson, H (1946) 'Philosophical Intuition' (Address at the 4th International Congress of Philosophy, Bologna, Italy April 5–11th 1911) in *CM* pp. 126–152
24. Ibid. p. 151
25. The linguistics of Saussure and the poststructuralist turn that flowed from it stress how language is a system wherein all the symbols relate only to each other, with no connection to the objects to which they refer. The concept captured by a linguistic notation innovation of the Greeks – namely, to use a double consonant to denote a sound where the consonant is pronounced for twice the length of time as the vowel, for example, in the word abba – Saussure termed, 'homogenous time'. I shall introduce Saussure's linguistics and the poststructuralist turn in Chapter 3, and the reader will hopefully see how closely related these two positions turn out to be. Bergson's relative knowledge, composed of symbols, is very well described by Saussure's linguistics. This break from an understanding of language where symbol and referent were directly linked, to one where language consisted in a self-referential system of symbols unconnected to the world of referents was key to the structuralist, and then poststructuralist turn. Saussure, of course, was writing at the same time as Bergson, and it is likely that he had read Bergson's work in the Revue Philosophique, although there is no evidence that Saussure's notion of 'homogenous time' comes directly from the concept of the *intuition philosophique* or *durée réelle*, only perhaps that these two very parallel re-imaginings of the nature of time arose simultaneously. See Joseph, J. E (2012) *Saussure* Oxford: Oxford University Press.
26. Bergson, H (1946) 'Philosophical Intuition' (Address at the 4th International Congress of Philosophy, Bologna, Italy April 5–11, 1911) in *CM* p. 151
27. Bergson, H (1946) 'The Perception of Change: First Lecture' (Address at the University of Oxford, May 26th and 27th 1911) expanded version published in *CM* p. 164
28. Ibid. p. 164

29. Ibid. p. 167
30. Ibid. p. 166
31. *IM* in *CM* p. 222
32. Bergson, H (1946) 'Introduction Part II Stating the Problems', in *CM* p. 35
33. *TFW* pp. vii
34. *TFW* p. 6
35. *TFW* p. 7
36. *TFW* p. 9
37. *TFW* p. 17
38. *TFW* p. 17
39. *TFW* p. 32
40. *TFW* p. 33
41. *TFW* p. 34 – interesting to note, here, that Bergson does not, here or anywhere in his published work that I have found, explicitly restrict consciousness to human beings
42. *TFW* p. 34
43. *TFW* p. 38
44. Aristotle, *Physics* VI: 9, 239b15 http://classics.mit.edu/Aristotle/physics.6.vi.html
45. Ibid.
46. Bergson, H (1946) 'The Perception of Change: Second Lecture' (Address at the University of Oxford, May 26th and 27th 1911) expanded version published in *CM* p. 170
47. Cajori, F (1920) The Purpose of Zeno's Arguments on Motion, *Isis*, 3(1), p. 11 http://www.jstor.org/stable/224191
48. Ibid. p. 15
49. Bergson, H (1946) 'The Perception of Change: Second Lecture' (Address at the University of Oxford, May 26th and 27th 1911) expanded version published in *CM* p. 171
50. *TFW* p. 77
51. *TFW* p. 82
52. *TFW* p. 82
53. *TFW* pp. 82–83
54. *TFW* p. 87
55. *TFW* p. 87
56. *TFW* p. 103
57. *TFW* p. 102
58. *MM* p. 21
59. *MM* p. vii
60. For example the work of Benjamin Libert
61. See the work of Walter Jackson Freeman III
62. Derrida, J (1976) *Of Grammatology* Baltimore: Johns Hopkins University Press
63. *MM* p. 7
64. *MM* p. 196
65. *MM* p. 7
66. *MM* p. 7
67. *MM* p. 7
68. *MM* p. 12

69. *MM* p. 17
70. *MM* p. 5
71. *MM* p. 30
72. *MM* p. 27
73. *MM* p. 5
74. Kilner, J.M., Neal, A., Weiskopf, N., Friston, K.J., and Frith, C.D. (2009) Evidence of Mirror Neurons in Human Inferior Frontal Gyrus. *The Journal of Neuroscience*, 29(32):10153–10159 also Rizzolatti. G and Craighero, L (2004) The Mirror Neuron System. *Annual Review of Neuroscience* 27:169–192
75. Rizzolatti. G and Craighero, L (2004) The Mirror Neuron System. *Annual Review of Neuroscience* 27:169
76. *ME* p. 7
77. *ME* p. 8
78. *MM* p. 24
79. Buckner, R.L. (2000) Neural origins of 'I remember' *Nature Neuroscience* 3(11): 1068–1069
80. *MM* p. 108
81. Buckner, R.L. (2000) Neural origins of 'I remember' *Nature Neuroscience* 3(11): 1068–1069
82. *MM* p. 87
83. *MM* p. 83
84. *MM* p. 130
85. Libet, B (1985). Unconscious cerebral initiative and the role of conscious will in voluntary action. *The Behavioral and Brain Sciences* 8: 529–566.
86. Llinás, R. (2001) *I of the Vortex: From Neurons to Self* (MIT Press, Cambridge, MA.)and Gregory, R (1968) Perceptual illusions and brain models. *Proceedings of the Royal Society B 171* 179–296 and Gregory, R (1998) Brainy Mind. *British Medical Journal* 317:1693–1695
87. Greenfield, S. (2000). *Brain Story*, BBC p. 75
88. Ibid. p. 79
89. Grandin, T and Johnson, C (2005). *Animals in Translation*. New York: Scribner. p. 121
90. Gregory, R (1968) Perceptual illusions and brain models. *Proceedings of the Royal Society B 171* 179–296
91. *ME* p. 9
92. *MM* pp. 183–184
93. *MM* p. 193
94. *MM* p. 194
95. *MM* p. 246
96. *MM* p. 246
97. *MM* p. 247
98. *MM* p. 248
99. It is interesting to note that Paul Virilio took up this argument, in his work on Speed, and described it as the 'picnoleptic' illusion, in Virilio, P (1986[1977]) *Speed and Politics: An Essay on Dromology.* New York: Semiotext(e).
100. *MM* p. 248
101. *MM* p. 251
102. *MM* p. 254
103. *MM* p. 255

104. *MM* p. 255
105. *MM* p. 256
106. *MM* p. 259
107. *MM* p. 260
108. *MM* p. 262
109. *MM* p. 267
110. *MM* p. 272
111. *MM* p. 273
112. *MM* p. 276
113. *MM* p. 279
114. Darwin, C (1859) *On The Origin of Species* An Electronic Classics Series Publication http://www2.hn.psu.edu/faculty/jmanis/darwin/originspecies.pdf p. 290
115. Ibid. p. 79
116. Gould, S. J. And Lewontin, R. C., (1979) The Spandrels Of San Marco And The Panglossian Paradigm: A Critique Of The Adaptationist Programme, *Proceedings Of The Royal Society Of London, Series B*, 205(1161): 581–598
117. Purcell S (2002). Variance components models for gene-environment interaction in twin analysis. *Twin Research*, 5(6): 554–571
118. Gould, S. J. And Lewontin, R. C., (1979) The Spandrels Of San Marco And The Panglossian Paradigm: A Critique Of The Adaptationist Programme, *Proceedings Of The Royal Society Of London, Series B*, 205(1161): 581–598
119. Gould, S. J. (2002) *The Structure of Evolutionary Theory* Cambridge: Harvard UP p. 66
120. Ibid. p. 58
121. Ibid. p. 20
122. Ibid. p. 144
123. Ibid. p. 2
124. Ibid. p. 3
125. Ibid. p. 36
126. Ibid. p. 21
127. Ibid. p. 21
128. Alvarez LW, Alvarez W, Asaro F, Michel HV (1980). Extraterrestrial cause for the Cretaceous–Tertiary extinction. *Science* 208 (4448): 1095–1108
129. Morgan, C. L. (1923) *Emergent Evolution*, London: Williams and Norgate https://archive.org/stream/emergentevolutio032372mbp#page/n5/mode/2up
130. Haldane, J. B. S. (1932) *The Causes of Evolution* London: Longmans Green https://archive.org/details/causesofevolutio00hald_0
131. Huxley, J. S. (1942) *Evolution, the modern synthesis* London: Allen & Unwin
132. Gould, S. J. (2002) *The Structure of Evolutionary Theory* Cambridge: Harvard UP p. 85
133. Ibid. p. 1213
134. Ibid. p. 13
135. *CE* p. 63
136. *CE* p. 64
137. Burwick, F., Douglass, P. eds. (1992). *The crisis in modernism: Bergson and the Vitalist Controversy*. Cambridge: Cambridge University Press. p. 160
138. Land, M.F. and Nilsson, D.E., (2002) *Animal Eyes*, Oxford: Oxford University Press

139. *CE* p. 70
140. See, for example, Land, M.F. (1965) Image formation by a concave reflector in the eye of the scallop, Pecten Maximus. *J Physiol*. Jul 1965; 179(1): 138–153, and McReynolds, J.S. and Gorman, A.L.F. (1970) Photoreceptor Potentials of Opposite Polarity in the Eye of the Scallop, Pecten Irradians, *J Gen Physiol* 56(3): 376–391.
141. Land, M.F. (1965) Image formation by a concave reflector in the eye of the scallop, Pecten Maximus. *J Physiol*. Jul 1965; 179(1): 138
142. *CE* pp. 64–65
143. *CE* pp. 65–66
144. *CE* p. 66
145. *CE* p. 67
146. *CE* p. 71
147. Bateson, W (1894) *Materials for the Study of Variation*, London: MacMillan https://archive.org/details/materialsforstud00bate
148. de Vries, H (1905) *Species and Varieties: Their Origin by Mutation*, London: Kegan Paul https://archive.org/details/speciesvarieties00vrieuoft
149. *CE* p. 71
150. *CE* p. 72
151. Eldredge, Niles and S. J. Gould (1972). 'Punctuated equilibria: an alternative to phyletic gradualism' In T.J.M. Schopf, ed., *Models in Paleobiology*. San Francisco: Freeman Cooper. pp. 82–115. Reprinted in N. Eldredge *Time frames*. Princeton: Princeton Univ. Press, 1985, pp. 193–223
152. Mayr, Ernst (1954). 'Change of genetic environment and evolution' In J. Huxley, A. C. Hardy and E. B. Ford. *Evolution as a Process*. London: Allen and Unwin, pp. 157–180.
153. *CE* p. 72
154. Darwin, C (1859) *On The Origin of Species* An Electronic Classics Series Publication http://www2.hn.psu.edu/faculty/jmanis/darwin/originspecies.pdf p. 18
155. Ibid. p. 19
156. *CE* p. 75
157. *CE* p. 75
158. *CE* p. 75
159. *CE* p. 76
160. *CE* pp. 76–77
161. *CE* p. 79
162. *CE* p. 79
163. *CE* p. 81
164. *CE* p. 83
165. *CE* p. 84
166. *CE* pp. 85–86
167. *CE* p. 86
168. *CE* p. 94
169. *CE* p. 25
170. *CE* p. 94
171. *CE* p. 25
172. *CE* p. 95
173. *CE* p. 95

174. *CE* p. 95
175. *CE* p. 95
176. *CE* p. 96
177. *CE* p. 97
178. *CE* p. 100
179. *CE* p. 102
180. *CE* p. 102
181. *CE* p. 107
182. *CE* p. 108
183. *CE* p. 108
184. *CE* p. 25
185. *CE* p. 109
186. *CE* p. 111
187. *CE* p. 116
188. *CE* p. 111
189. In this Bergson foreshadowed the work of E.O. Wilson, such as his (2012) *The Social Conquest of Earth* London: Liveright.
190. *CE* p. 112
191. *CE* p. 113
192. *CE* pp. 113–114
193. *CE* pp. 113–114
194. *CE* p. 120
195. *CE* p. 120
196. *CE* p. 122
197. *CE* p. 122
198. *CE* p. 122
199. *CE* p. 123
200. *CE* p. 133
201. *CE* p. 133
202. *CE* p. 140
203. *CE* p. 140
204. *CE* p. 140
205. *CE* p. 141
206. *CE* p. 149
207. *CE* p. 149
208. *CE* p. 153
209. *CE* p. 160
210. *CE* p. 165
211. *CE* p. 169
212. *CE* p. 170
213. *CE* p. 171
214. *CE* p. 173
215. *CE* p. 174
216. *CE* p. 176
217. *CE* p. 182
218. See Note 25 above on Saussure.
219. *CE* p. 179
220. *CE* p. 194
221. *CE* p. 200

222. *CE* p. 200
223. *CE* p. 206
224. *CE* p. 207
225. *CE* p. 225
226. *CE* p. 265
227. *CE* p. 268
228. *CE* p. 271
229. *CE* p. 297
230. *CE* pp. 276–277
231. Burwick, F., Douglass, P. eds. (1992). *The crisis in modernism: Bergson and the Vitalist Controversy*. Cambridge: Cambridge University Press. p. 4
232. *CE* p. 281

3
Bergson Redux

Eclipse

Why did Bergson, one of the most famous and highly regarded philosophers of the first decades of the 20th century[1] – one of the 'Select Forty' of the *Académie Française* and a Nobel Laureate – so swiftly fall from sight, become, to all intents and purposes, a mere footnote and curiosity in histories of philosophy, by the 1980s? In 2000, when I first became interested in Bergson, little of his work was actually still in print in Britain. I was able to acquire, in a second-hand bookshop in Wells, Somerset, however, a 1944 US edition of Arthur Mitchell's 1910 translation of *Creative Evolution*, with a Foreword written by Irwin Edman, as the very darkest days of the Second World War began to lift in December 1943, which gave a clue.

Edman was a recognisably American Professor of Philosophy at Columbia, NY, (where Bergson had given invited lectures in 1913), and wrote books on the Greeks, on Schopenhauer, Dewey, and Santayana. Such a leaning toward pragmatism must have contributed to making him an admirer of Bergson's. William James, another great American pragmatist philosopher, was a vocal supporter of Bergson's work, as well as a long-term correspondent, as we have seen. In essence, in his Foreword, Edman explains in his characteristic lucid and approachable style, that Bergson's philosophy carries with it, alongside its fascinating challenge, both great responsibilities and great dangers. If the intellect is indeed to be demoted from the rationalist pinnacle to which the 19th century had reified it, if our intuitive faculties are truly the greater, then a gigantic doorway is opened. As Edman says, 'The *élan vital* means a renaissance to a poet; to a barbarian it means brute power.'[2]

As Levi-Strauss amply demonstrates on many occasions in his studies of world mythology,[3] at the threshold of every door there is a guardian – a gargoyle. If, as Edman suggests, Bergson's work opens a great door for Western thought, it is my reading of the fall of Bergson's philosophy from favour that the Nazis were the demon at the gate, and that having defeated them and retreated from that gate back into the primacy of intellection, the Western world was loath – for some decades – to risk that road again. In short, Bergson was (wrongly) defined as a vitalist, and all the vitalists then tarred with the stain of Nazism.

This happened over many decades, beginning in the late 19th century. Vitalism, once a popular counterpoint to the 19th century view that organisms were machines, became also a tool of less than savoury political agendas. Biologist Hans Driesch, whose vitalist concept of entelechy he popularised in the Gifford Lectures in Edinburgh in 1907 and 1908, was singled out in particular for condemnation in Bakhtin's 1926 survey of 'Contemporary Vitalism,'[4] although it was arguably those who used Driesch's ideas to support their own politics that so enraged Bakhtin.

A 'vulgar vitalism' had begun to flourish, growing in the last decades of the 19th century, fleshed out with ideas from Spencer's *Social Organism*[5] and Francis Galton's eugenic notions of 'national selection,'[6] which placed white Europeans at the pinnacle of a finalist and vitalist evolutionism, and fed into both British Empire policy for refreshing the stock of the British population,[7] and, by the 1930s, the Aryan mythology of the Nazis. 'Nazism,' after all, was '"applied biology,"' according to Hitler's deputy Rudolf Hess.[8] This 'vulgar vitalism' ultimately polarised opinion across the Western world. 'The National-Socialist creed is in fact a vitalist pantheism,'[9] announced *The Tablet* – the international Catholic News Weekly, in 1938.

But neither vitalism itself, nor Bergson in particular, was guilty of the political agendas of those who used vitalism for their own ends. Driesch was forcibly retired from his post in a German university in 1933 for refusing to endorse the National Socialist party. Bergson, born a Jew, latterly a convinced Roman Catholic, refused to officially convert as he approached death in Paris, in 1941, preferring to maintain his status as Jew in sympathy with his brethren both in France and Germany. Neither had any support for the Nazi interpretation of vitalism. Bergson's *Creative Evolution* in particular had not, 'in reality, resorted to anything remotely like a mysterious "fluid", as had such early "substantival" vitalists as Willis or Stahl.'[10]

But, Bergson's concern with the *élan vital,* and his stance against rationalism in his *intuition philosophique,* had pitted him against some strong and vocal critics – such as Bertrand Russell, who wrote a short book critiquing Bergson,[11] and even Santayana, who also penned a short study.[12] Many of these critics included Bergson with the broader neo-vitalist movement of his time, and the social context to which it contributed. To Burwick and Douglass, the eclipse of Bergson suggests a disturbing possibility: 'that his work is a repressed content of modern thought.'[13]

In fact, Bergson actually criticised vitalism explicitly in *Creative Evolution*, citing the work of both Driesch and Johannes Reinke. The two lines of 'contemporary neo-vitalism' as he describes them, were, on the one hand, the assertion that pure mechanism is insufficient, and on the other, the various hypotheses the vitalists attempted to try to explain things. The first line, as Bergson says, diplomatically, 'is perhaps the more interesting.'[14] In this, he has excellent contemporary company. Ernst Mayr, one of the 20th century's leading environmental biologists, declared in 2002 that, 'When one reads the writing of one of the leading vitalists like Driesch, one is forced to agree with him that many of the basic problems of biology simply cannot be solved by a philosophy as that of Descartes, in which the organism is simply considered a machine.'[15] Unfortunately, in the same lecture, continuing a tradition begun decades earlier, Mayr lumps Bergson and Driesch together as early 20th century vitalists.[16] For both Bergson and Mayr, however, the attempt by the vitalists – such as Driesch – to explain things is where 'the stumbling-block of the vitalistic theories'[17] lay. Mayr, it seems, is another one of Bergson's critics who'd never read any Bergson.

Bergson's argument, without the intervening century of biological science behind Mayr's answer, was characteristically around dualisms. As we have seen in the last chapter, Bergson rejects both 'radical mechanism' and 'radical finalism' in *Creative Evolution*. In his argument against finalism, he spends a few pages – almost as an aside – pointing out the problem the vitalists have. 'We shall not reproach them,' he begins, 'as is ordinarily done, with replying to the question by the question itself: the "vital principle" may indeed not explain much, but it is at least a sort of label affixed to our ignorance, so as to remind us of this occasionally, while mechanism invites us to ignore that ignorance.'[18] The problem for the finalists lies in the location of any such vitalist principle: in the organs that make up an individual? In the individuals that make up a population? The finality of Aristotle's *causa finalis* cannot exist either inside the individual or at the level of the individual, but only if it 'includes the whole of life in a single indivisible embrace.'[19] The error of such finalism – and of mechanism, as we have seen – lies in the habits of intellection. Both are, as Bergson explains in *Creative Evolution,* false problems when viewed through the lens of the *durée réelle.*

Bergson's philosophy, clearly, was much deeper and more penetrating than the critics of intuition and of vitalism understood. What he meant by *intuition philosophique*, and *élan vital,* indeed, was very different from what his critics claimed. The pragmatist philosopher William James had said admiringly that Bergson had 'killed intellectualism definitively and without hope of recovery.'[20] Recover, however, it did: perhaps in part due to the funding mechanisms for academic research in the post-war, as we shall see in the next chapter. Perhaps simply because after the ravages of war the certainties of rationalism offered a comfort the radical uncertainty of creative evolution does not hold forth.

As Kolakowski suggests, in the after war years, in France, came the bleak and highly intellectual world of existentialism – the generation of Sartre and Merleau-Ponty. They were all, of course, 'well acquainted with Bergson's work. None of them was "Bergsonian" in a recognizable sense, but none of their ideas was conceivable without Bergson's legacy.'[21] The growing popularity – not least with Sartre and Merleau-Ponty – of Bergson's German contemporary, Husserl (also born in 1859), and some of the post-war phenomenologists, such as Heidegger,[22] probably also contributed to Bergson's eclipsing in the halls of academe – more by historical accident perhaps than anything else. Importantly, without a clearly recognisable methodology – such as Husserl's, which attempted a similar rigour to the physical sciences – once the man himself was gone, having given so many lectures around the world explaining his thought, rather than concentrating on building a school of postgraduate followers (as Husserl did), Bergson's philosophy, in a sense, in the swirl of the world war and its aftermath, died with him. The gnosticism of the *Two Sources* no doubt contributed to his demise.

The 1960s

It was not until the mid 1960s – when Gilles Deleuze turned from Nietzsche, Kant and Proust, to Bergson – that the great philosopher's ideas began their road back to respectability and popularity. Today all of Bergson's works are in print once more in Britain, the US and elsewhere, and there is burgeoning interest in his ideas. Deleuze's *Le Bergsonisme*, published in 1966, as Mullarkey suggests, 'is partly responsible for this resurgence.'[23] Key to this revitalisation, for Deleuze, was Bergson's concept of multiplicity, and all that it implied. Heidegger and the phenomenologists' notion of being as a unity was the target, Bergson was the weapon.

But multiplicity is not the only concept of Bergson's that has experienced resurgence. The question of time in scientific thinking has returned and continues to vex many in the physics community, specifically with respect to irreversibility. The distinction between the 'closed' and the 'open', moreover, so crucial to the *Two Sources*, has indeed become key to many more understandings of the world.

On Deleuze

Gilles Deleuze's *Le Bergsonisme*, and the relationship to Bergson's ideas to be discovered elsewhere in poststructuralist thought – for example, in Foucault and in Derrida – suggest that, although the life and reputation of the man were eclipsed after the war years, his ideas had penetrated at least the world of French philosophy in a fundamental and ineradicable manner. For Deleuze, Bergson forms part of a counter history of philosophy. He was a writer like Lucretius, Spinoza, Hume or Nietzsche, 'who seemed to be part of the history of philosophy, but who escaped from it in one respect or altogether.'[24]

In Deleuze's study of Bergson, the crucial point is that he has re-imagined Bergson as a precursor of the 'poststructural turn': philosophy turning its own powers back upon itself, reflecting upon its own flaws, gaps, and limitations – philosophy as an act of self-consciousness. 'He sees Bergson's *intuition philosophique* as the first clear statement of the poststructuralist turn as method.'[25] Intuition, in short, for Deleuze, is the method of Bergsonism: 'Intuition is neither a feeling, an inspiration, nor a disorderly sympathy, but a fully developed method. One of the most fully developed methods in philosophy. It has its strict rules, constituting that which Bergson calls "precision" in philosophy.'[26]

This is of particular significance when one considers that it was perhaps the lack of a distinct Bergsonian method which enabled Husserl's more developed methodology to prevail in the post-war years. Indeed it might be said that this identification and explication of *intuition philosophique* by Deleuze played a crucial and fundamental role in the rediscovery and ongoing increasing interest in Bergson.

The first chapter of Deleuze's book, then, is given over to 'Intuition as Method,' in which he isolates three basic rules. The first concerns the staging and creating of problems; the second, the discovery of genuine differences in kind; the third, the apprehension of real time. The first two of these rules also have 'complementary rules,' ending in five, rather than three essential elements. These rules, Deleuze delineates as follows:

1. First rule: 'Apply the test of true and false to problems themselves. Condemn false problems and reconcile truth and creation at the level of problems.'[27]
   a. Complementary rule: *'false problems are of two sorts, 'non-existent problems,' defined as problems whose very terms contain a confusion of the 'more' and the 'less'; and 'badly stated' questions, so defined because their terms represent badly analysed composites.'*[28]
2. Second rule: 'struggle against illusion, rediscover the true differences in kind or articulations of the real.'[29]
   a. Complementary rule: *'the real is not only that which is cut out (se découpé) according to natural articulations or differences in kind; it is also that which intersects again (se recoupé) along paths converging toward the same ideal or virtual point.'*[30]
3. Third rule: 'state problems and solve them in terms of time rather than of space.'[31]

Thus, the process of stating problems is itself problematised in Deleuze's reading of Bergson, and it is immediately clear that Deleuze's own interest in multiplicities and difference arises from the method he so clearly picks out in this chapter. What is true and what is false, when applied to problems and their solutions, may be (relatively) straightforward. But the nature of truth and falsehood in regard to the posing of problems is not. 'Conscious of the need to take the test of true and false beyond solutions into problems themselves [many philosophers] are content to define the truth or falsity of a problem by the possibility or impossibility of its being solved. Bergson's great virtue, on the other hand, is to have attempted an intrinsic determination of the false in the expression "false problem."'[32] This is a profound interpretation. I have described – in the opening of Chapter 2 – as 'characteristic,' behaviour by Bergson, when he takes both sides of a dualistic argument and shows what they have in common, and how the argument between them dissolves when the error in what they have in common is revealed. This 'characteristic' behaviour is formalised by Deleuze as a distinct philosophical method that can be followed: the first rule.

The most fundamental 'false problem' – from which many others are derived – is the notion of the negative and of negation, popular in analytical philosophy for centuries, and for Bergson an intellectual trap he demolishes in the last chapter of *Creative Evolution*. As Deleuze explains, Bergson's arguments help us to understand that the notion of non-being is paradoxical: 'there is not less, but more in the idea of non-being than that of being, in disorder than in order, in the possible than in the real.'[33] To posit the pre-existent is to add something to the existent. 'In the idea of non-being there is in fact the idea of being, plus a logical operation of generalised negation ... In the idea of disorder there is already the idea of order, plus its negation, plus the motive for that negation.'[34] Being; the existent: these are self-sufficient truths that do not require an intellectually constructed 'falsity'; such a distinction is the root of many of the 'false problems' Bergson addresses.

As well as false problems, as adjunct to the first rule, what I have pointed out as Bergson's series of 'favourite distinctions' – for example, between whether things differ in *kind* or in *degree* – Deleuze here characterises as 'badly stated' problems: problems where two different aspects are conflated, or where one side of a problem is represented in the terms of the other. As explored in the last chapter, differences between *quality* and *quantity* are often teased apart by Bergson, as well as differences between *space* and *duration*. 'Order,' as a general idea that could be counterposed with a similarly general idea of 'disorder,' is indeed just such a badly composed composite. It is a badly stated problem, focussed only on differences in *degree*, between more and less, upon the 'measure' of everything, when in fact there are also differences in *kind* that make such a notion of a generalised 'order,' comprising both what is measurable and what is not susceptible to measure, not only nonsensical but misleading. *Intuition philosophique* grants us the critical faculty to tease out the differences in *kind* that help us to distinguish between true and false problems.

Deleuze can then summarise intuition as a method of division. As I have pointed out, Bergson often presents us with pairs of opposites that he assures us are never found alone, purely one or purely the other, but always, in reality, in combination. In fact, Deleuze assures us, 'experience in itself offers us nothing but composites.'[35] The second rule of intuition as method, then, is to imagine each half of these pairs in its pure state, in order better to understand them, and their combination, and to see the differences in *kind* that will enable us truly to grasp the real. In doing so we will also grasp, in the complementary rule to this second rule, that this dualistic philosophy of understanding the divisions is also a monistic philosophy apprehending the composite as it truly is: seeing how all the differences in kind ultimately intersect once more 'along paths converging toward the same ideal or virtual point.'[36]

Understand we must the differences between the two sides of a coin, but one coin it remains.

Lastly, Deleuze accords a rule unto itself to the most crucial of Bergson's 'favourite distinctions': between *space* and *time*, enjoining philosophers using the method of *intuition* to understand that mobility is key to the real, that fixity is an illusion, and that all philosophical problems should be posed and solved in the register of duration. The *intuition philosophique,* in Deleuze's re-imagining it as a method with clear rules, thus becomes the foundation for the poststructuralist turn.

On the poststructuralist turn

It will be instructive, at this point, for us to briefly review what the poststructuralist turn might be said to be, and how it came about. The history of philosophy has taken many turns and Deleuze's reading of Bergson's place within it is of particular note.

Firstly, the poststructuralist turn must be understood in the context of the linguistic turn. Bertrand Russell's protégé Ludwig Wittgenstein may be considered one ancestor of the linguistic turn. However, for poststructuralism the crucial break with the past was made before then by the linguist and father of structuralism, Ferdinand de Saussure (1857–1913). Many different intellectual movements and developments through the 20th century are associated with the linguistic turn. Here, those that are considered are viewed from a poststructuralist perspective. Their main philosophical outcome in the 1960s/70s and up to the present day is poststructuralist philosophy, but there are other strands of linguistic theory that have led in different directions.

Saussure was a contemporary of Nietzsche (1844–1900) and of Bergson and the writings of all three can be considered contributors to the philosophical position of poststructuralism. If structuralism was the initial outcome of Saussure's linguistic turn, it arguably became poststructuralism with the input of Nietzsche and Bergson. Structuralism's major theorists following Saussure were Claude Levi-Strauss,[37] who focussed on the structuralism of myth; Roland Barthes,[38] who focussed on structural semiotics; Louis Althusser,[39] who re-interpreted Marxist thought from a structuralist perspective; and Jacques Lacan,[40] who re-interpreted Freud from a structuralist perspective. All these authors were also influenced by poststructuralism, which was, in a nutshell, critical of structuralism's attempt to become a strict 'scientific' endeavour. The originators of poststructuralism in the 1960s, some of whom were also associated with structuralism, include Deleuze,[41] who re-introduced and re-interpreted (among others) the ideas of Nietzsche, as well as of Bergson, and focussed upon the relationship between identity and difference; Michel Foucault[42] who focussed upon power, social institutions, and the decentred self; and Jacques Derrida,[43] whose primary project was *deconstructionism* and *différance*. Influential poststructuralist theorists thereafter include the postfeminists Judith Butler,[44] Luce Irigaray,[45] and Julia Kristeva.[46]

However, Emile Durkheim's (1858–1917) ideological opposition of individual and society, and a concern with the *conscience collective* – ideas which persist through Parsons and Habermas to the present day, albeit principally in the form of social science, as opposed to sociology – remain rooted in Enlightenment philosophy, and provide a continued Lockean, positivist philosophical strand for those wishing to consider the social, without embracing the linguistic turn.

On the linguistic turn

The linguistic turn is characterised by a break with what had been the orthodox concept of language since the Enlightenment. To understand the linguistic turn, therefore, we must first consider what the Enlightenment orthodoxy was, and then how Saussure broke from it.

Building on the philosophical stance established by Descartes, and the foundational dualism it introduced, John Locke (1632–1704) and Marquis de Condorcet (1743–1794), among others, can be considered the fathers of the Enlightenment conception of language. There are two basic elements to this conception. Firstly, that language is separate from, and a mere gloss on, what actually exists outside of discourse. Thus, the meaning of a word is deemed to be the object (outside of language) to which that word refers. Language, therefore, is seen as a set of signs depending on their relation to things lying outside of language. Secondly, to make this relationship between signs in language and things outside of it work, there has to be a 'guarantor' of the relationship between the two: the human subject. The human subject is claimed to be (and must be, in order to act as guarantor) a rational being in full control of his/her consciousness, who assigns meanings to words and ensures their correct usage.[47] This rational human subject, to which objects are represented by language, uses that language to express his/her being in the form of identities, roles, etc., related to social structure, based on innate desires for co-operation and self-improvement: 'human nature'. This is traditional liberalism, in which the human subject can be trusted to be a force for social order and advancement.

Saussure criticised this approach to language as a simplistic word listing with corresponding objects. In keeping with Nietzsche's criticisms of Plato's Theory of Ideal Forms,[48] he criticised the assumption that ideas came ready-made, pre-existing words, awaiting only the rational human subject to assign the correct words to them. By contrast, Saussure claimed that 'the linguistic sign unites not a thing and a name, but a concept and a sound-image.'[49] The 'sound-image' is Saussure's concept of the 'psychological imprint of the sound, the impression that it makes on our senses.' A linguistic sign then becomes a coin with two faces – concept and sound-image – which he names signified: the mental representation of the meaning; and signifier: the psychological imprint of the sound. Signified and signifier should never be thought of as separate. This semiological conception of language brings idea and sound together, and puts the study of language firmly into the purview of sociology. The linguistic sign, in this conception, is completely arbitrary. It has no reference to any extra-linguistic reality, and is defined only in reference to other linguistic signs. In fact it is defined in relation to *all* other linguistic signs, by its *difference* from them. Thus, word-sounds are attached to concepts, rather than to the objects in the real world that such concepts are about. Language and thought thus come together – inseparable, in fact – for there cannot be a thought without language. 'Without language, thought is a vague, uncharted nebula. There are no pre-existing ideas, and nothing is distinct before the appearance of language.'[50]

The classic example, of course, is the multiple words the English have for rain, where in other languages there are just one or two, or the multiple words Eskimos have for snow, where in English there are just one or two. Languages differ in the way they divide up reality, powerfully influenced by their social context. The only constraint, therefore, upon the arbitrariness of language, is the logic within its rules of grammar, syntax, etc. Indeed, without such arbitrariness, language would never change, for the possibility of words going out of common usage, or of new ones coming into usage, and the gradual shifts of meaning associated with certain words common to all languages, would be precluded. Thus, for Saussure the study of language became a study of language as a system, in which differences carry signification. Indeed, for Saussure in language there are only differences: every word is a nexus or node of such differences. Importantly, language (*langue*), for Saussure, was distinct from speaking (*parole*). Where the former was social, the latter was individual, and language should be viewed as a potential never complete in any individual speaker. Saussure's linguistic project was to establish a scientific rigour for *langue* as a formal system.

Bergson's own ideas on language are both contemporary with Saussure's and very similar. As we saw in the last chapter in his arguments concerning Kant's notion of absolute knowledge, Bergson understands relative knowledge as calling upon symbols and generalised ideas and fragments of knowledge that tries to weave a patchwork description around a thing that inevitably distorts it. Representation, symbol and interpretation are for Bergson the character of relative knowledge:

> *The instinctive sign is* adherent, *the intelligent sign is* mobile.... The word, made to pass from one thing to another, is, in fact, by nature transferable and free. It can therefore be extended, not only from one perceived thing to another, but even from a perceived thing to a recollection of that thing, from the precise recollection to a more fleeting image, and finally from an image fleeting, though still pictures, to the picturing of the act by which the image is pictured, that is to say, to the idea.[51]

The Moscow Linguistics Circle, based on Saussure's work, sought to unravel the structural laws of linguistics and poetics, and Benveniste, among the French linguists, took these ideas further; it was from here that the word 'structure' came to be favoured as against 'system'. Whereas systems can be open, structure cannot, and language was not seen by these linguists as an 'open' system, but rather as closed: hence, structuralism.[52]

On structuralism

This semiological conception of language as having an internal structure has profound implications for the former (Lockean) guarantor of the relationship between language and the 'real' world: the human subject. Not only is the sense of a word or sentence no longer to be found in anything external to language, the human subject is also no longer the source of its meaning. The arbitrariness of signs, and their reliance on difference, means all signs must exist in a structure that works through internal coherence only, rather than through any relationship to anything outside of it. In this structure the human subject – the individual engaged in speaking (*parole*) – cannot any longer be regarded as the source of meaning in a wider system (or structure) of language (*langue*), in the Enlightenment sense of providing the guarantee of the relationship between word and (extra-linguistic) object. The subject, by contrast, becomes an *effect* of wider processes that pre-exist outside of it. This 'decentring' of the human subject is perhaps the most profound outcome of Saussurian linguistics, in philosophical terms, and a key common thread throughout all structuralist and poststructuralist thought, often depicted as anti-humanism, (assuming humanism places the individual subject at the centre of the universe).

Linguistic structure was rapidly generalised into structuralism as an approach that could be applied to other problems in the humanities. The anthropologist Claude Levi-Strauss (1908–2009), through working with Jakobson of the Moscow Linguistics Circle, discovered Saussure and extended the structural conception of language to the social world. Levi-Strauss posited that deep mental structures exist in humans that manifest themselves in social structures. In this way, however, he held on to a form of rationalism, through a Durkheimian focus on the opposition of individual and society. This is not the place to go into Levi-Strauss's elaborate contentions concerning the incest taboo. More interesting is that he focussed more on mental representations of 'reality' than on any historical/factual descriptions in his anthropological studies, and thereby extended the approach of linguistics. The psychoanalyst Jacques Lacan (1901–1981), meanwhile, learning from Levi-Strauss and Jakobson about Saussurian linguistics, sought to re-interpret Freud from a structural perspective, denying any biological base underlying conscious experience. Louis Althusser (1918–1990), shortly thereafter, did for Marx what Lacan had attempted with Freud. Yet here, with Althusser, and then with Foucault (his pupil), structuralism begins to morph into post-structuralism.

On poststructuralism

Louis Althusser's (post)structuralist Marxism focussed around the concept of ideology. Ideology for Althusser was not a matter of 'ideas', but something which operates without the knowledge of any pre-existing author: a series of material practices or rituals embedded in material institutions, a structural feature of any society; a material existence which only exists in an apparatus and its practice or practices. Everything but the material, for Althusser, was ideological. Ideology occupied the realm of social practice rather than being some entity that determined practices. The echoes of Gramsci's cultural Marxism – and his notion of hegemony – are clear.

For Althusser it was ideology, moreover, that constituted the individual subject. 'Ideology serves to obscure the reality which derives from the economic order and, in this respect, the function of ideology is to reproduce the economic order'.[53] To the extent that this Althusserian notion of ideology remained structuralist, rather than poststructuralist, however, it remained prone to accusations of functionalism – that ideology determined everything in society and that escape was impossible. Embedded as it was in social practices and in material apparatuses – schools, religious institutions, the family and so on – Althusserian ideology became inescapable.

Althusser taught at the École Normale Supérieure, where Bergson had both studied and worked, and was Philosophy tutor to Michel Foucault (1926–1984), who, in his genealogical analysis of institutions, from prisons to mental hospitals to the nature of sexuality, saw the micropolitics of power everywhere, but located it at the level of the individual: a web of interrelations immanent between people, not wielded by one over another. The individual subject was not only no longer at the centre, as for Saussure, but itself as contingent and co-determined as the language it uses. For Foucault the notion of scientificity itself, all the disciplines of scientific endeavour, the very idea that knowledge could grasp at truth, dissolved in the intrinsically political nature of discourse, the contingency of language. The structuralist project to find laws on the model of the physical sciences within language and sociology founders immediately one grasps the inherent contingency of all knowledge, the impossibility of 'Truth.' The genealogical interpreter is all too conscious not just of where he/she stands in history, but of the historically contingent nature of the construction of his/her selfhood that undertakes the interpretation.

This poststructuralist turn looked back, not only to Bergson, as I will elaborate in a moment, but also to Friedrich Nietzsche. Now, for Nietzsche humankind is trapped with language; there is no knowledge beyond language, no positive facts, merely interpretations: objectivity is a fiction. It is impossible to achieve a total and absolute view of the world; 'truth' is equated with falsehood. The history of philosophy, for Nietzsche, is the evolution of an error that reached its pinnacle with Kant: the error of loops. Kant's attempt to describe knowledge as concepts is for Nietzsche the quintessential error of Western philosophy: to claim that knowledge relies on concepts is to use the very tools that one is describing, and to question *how* knowledge is possible is to presume that knowledge *is* possible. The error of the history of philosophy is the assumption of the possibility of knowledge. Meaning thus becomes fluid – 'there being nothing apart from the meaning generated in the moment of interpreting words. Every sentence is created out of nothing. It is by the denial of the fixity of meaning, and only thereby, that the creation of new meaning is possible.'[54] As if heralding the work of Saussure and his inheritors, Nietzsche claimed that truth is 'A mobile army of metaphors, metonyms, anthropomorphisms… truths are illusions which are worn out and without sensuous power… to be truthful means to use the customary metaphors. The world is in a constant state of flux, always a world of becoming wherein nothing is eternal.'[55] Bergson's own insights into time indeed echo this assertion of mobility and flux in the universe.

Including these insights of Nietzsche's in the (post)structuralist project, of course, had a profound effect on the notion of *structure,* of the closed *system* of language. Where Saussure believed that the signified was the mental 'other half' of the signifier, that 'the meaning of the sign was *present* to the speaker when he uses it,'[56] Jacques Derrida (1930–2004) insisted that, on the contrary, the meaning of the sign is always unanchored, that the signified, (mental component) is itself only a sign that derives its meaning from other signs. The 'system' of language becomes, thereby, opened up: the signified becomes yet another signifier in the endless interrelationships and interactions between signifiers. Structure, then – by definition closed – it can no longer be.

The poststructuralist turn, then, in Althusser and in Foucault, as well as in some of the other writers mentioned here, incorporates at its root the Nietzschean critique of objectivity and 'truth', which feeds into 'Foucault's anti-rationalist position, where rationality is presented as historically constructed while simultaneously being an effect of power.'[57] But this anti-rationalist position also incorporates the critique of intellection we have seen offered by Bergson. Foucault's position on rationality is not merely that it is historically constructed but that such construction takes place within processes and flows whose only logic is internal, both within the confines of disciplines that reinforce their own notions of what is true, and in the broader episteme that is made up of nothing more than the current configuration of disciplines as they unfold. This process-based unfolding relies, moreover – though Foucault does not acknowledge it – on Bergson's 'favourite distinction', the Deleuzian third rule: the difference between space and time, the crucial significance of the *durée réelle*.

On Bergsonian poststructuralism

In short, the poststructuralist turn is a turn away from fixity toward mobility, and as such, couldn't be more Bergsonian. Crucially, moreover, this mobility is also multiple. This is clear in Bergson's characteristic distinction between pure duration and pure space. Pure duration, being only internal, cannot and does not exist. Space, which is its exteriority, cannot exist without duration. Differences in degree exist in space, differences in kind exist in duration. Discontinuity resides in the former, continuity in the latter. Both, however, are multiplicities, and it is Deleuze's argument that the concept of multiplicity is of the utmost importance. Indeed, much of Deleuze's poststructuralist philosophy can be said to rely upon this notion of multiplicity, as with Derrida's, and indeed Foucault's.

In his final work, in the third volume of *History of Sexuality*[58] and in late writings gathered in the volume *Technologies of the Self*,[59] Foucault accentuates the processual flow of 'taking care of the self,' as an ethical project on its own terms undertaken over time. The late Foucauldian poststructuralism, then, is a uniquely human 'turning' – for all its anti-humanist decentring – which keeps us open: keeps open all that, otherwise, would remain forever closed. In taking care of the self, the possibility of choice is reinserted into Foucault's previously disciplinated world, making the latter part of his oeuvre more distinctly poststructuralist, where the earlier was more structuralist, in the vein of Althusserian ideologies: inescapable.

Bergson's notion of intellection, though, incorporates just this paradox. The intellect looking outward and backward, in spatial and conscious terms, cannot understand evolution properly, in its durational, intuitive, inward and forward immediacy. As Deleuze points out 'it could be said that the living being turns on itself and closes itself'.[60] It takes an effort of will to turn back and face forward. Nonetheless, like Bergson, Deleuze 'sees man as the end-point of creation, for he enfolds all,' and 'durations that are inferior or superior are still internal to him. Man therefore creates a differentiation that is valid for the Whole, and he alone traces out an open direction that is able to express a whole that is itself open.'[61] The universe 'is organic *in the sense that it is virtual becoming in actualization*, and the key movement of that actualization is the "turn" in which this virtuality (also known as the *élan vital*), "gains self-consciousness"' – through us.[62] Clearly, consciousness, in this reading, is the centre of a united universe of composite multiplicities, and the present moment the fulcrum upon which reality hangs.

In the 1990s, Judith Butler's performative postfeminism drew (perhaps unconsciously) on Bergson's notions of perception and memory when she speaks of materiality being hinged upon the citation of pre-existing roles. She returns to the notion of matter and re-defines it as 'a process of materialization that stabilizes over time to produce the effect of boundary, fixity, and surface we call matter,'[63] just as Bergson would describe his 'images' – neither what the realist calls a 'thing' nor what the idealist calls a 'representation'. That most privileged image, the body, in Butler's analysis, is marked off through a process of erasing, of selectivity, which, through persistent reiteration, becomes a boundary that is defined rather by what it is not, than by what it is. The *usefulness* Bergson speaks of, by which what we perceive of objects is selected, is here politicised by Butler in the Foucauldian context of disciplinary society, such that the process of the reiteration of the pre-defined roles is what defines the boundaries of bodily matter: usefulness, in other words, to socially determined agendas. As Butler asserts, 'there is no reference to a pure body which is not at the same time a further formation of that body.'[64]

In sum, Deleuze's *Le Bergsonism*e interprets Bergson as a philosopher of 'difference.' It recognises and supports Bergson's evolutionism, points out his – both monistic and dualistic – schemes of differentiation, by which 'a unitary force, or *élan vital*, becomes actualised in divergent, opposed streams – matter and life, instinct and intelligence,' and lauds the *intuition philosophique* as method. Crucially, for Deleuze, it is about multiplicity and mobility, about difference: 'Evolutionism will always have the merit of reminding us that life is production, creation of differences'.[65]

In the wider poststructuralist turn, and the linguistic turn which fed into it, then, the work of Deleuze, Derrida, Foucault and Butler make Bergson's fundamental insights – *intuition philosophique,* the mobility and multiplicity of the *durée réelle,* the decentred subject whose contingent consciousness through the exercise of choice at the pivot of the present remains nonetheless the end-point of evolution, of the *élan vital* – the core, if not always stated messages of poststructuralist philosophy.

Contemporary resurgence

It is important to note, however, that the poststructuralist turn, although instrumental in bringing Bergson back into favour, has not been the exclusive realm of that renewed interest. Immediately following Deleuze's intervention in 1966, interest in Bergson did not – from the publication record – seem to grow much beyond the level it had reached after the Second World War (with perhaps Pete Gunter one of the few voices), until in the late 1980s and on into the 1990s finally growth in interest in Bergson and his work began to return. The following is not meant to be exhaustive, or even comprehensive, but presents a brief overview of some of the attention paid to Bergson in recent decades that is relevant to the current volume.

Almost 20 years after Deleuze's *Le Bergsonisme*, Polish philosopher and historian of ideas Leszek Kolakowski published his study, *Bergson*.[66] Kolakowski, although originally a communist himself, is famed for his critiques of Soviet communism, and for his later work on theology, including *Religion* (1982) in which he analyses a wide range of arguments for and against the existence of God. Three years later, his study of Bergson shares this interest, focussing, as it does, alongside lucid and straightforward explications of Bergson's core ideas, on the key issues of mind and body, and questions raised, in particular, in Bergson's 1912 essay, *Soul and Body*. Kolakowski, himself already in his late 50s by this time, explores the questions Bergson focussed on in his 50s, long after the key texts, *Time and Free Will* (1889), *Matter and Memory* (1896), and *Creative Evolution* (1907), and in the early gestation period of the final work of his life, *Two Sources of Morality and Religion,* published eventually in 1932. In keeping with such a focus, Kolakowski describes *Creative Evolution* as 'the boldest attempt to assimilate the theory of evolution to a world view which implied a Great Mind at the steering-wheel of the universe and the absolute irreducibility of the human soul to its material conditions.'[67] Kolakowski, then, reads divinity into the *élan vital* as many of Bergson's contemporary critics did. For Kolakowski, the key point of *Creative Evolution* was to show that the evolutionary process, 'although far from infallible, or planned in advance in all its details, unmistakably displays an internal purposefulness which can only be explained as the work of divine energy.'[68] Now, other interpretations of Bergson's notions of the energy of the evolutionary process in *Creative Evolution* are certainly possible – and indeed this volume offers one that does not have recourse to religious terminology – but by the time of *Two Sources of Morality and Religion* it is clear that Bergson did indeed believe that the universal spirit, the other side of the coin of matter, that *élan vital* which distinguished matter from life, was indeed 'divine'. Kolakowski's reading of Bergson's oeuvre has it that there is no process by which Bergson's interest in the divine was absent in his early work and his interest in science absent in his last work, but that both issues fascinated him throughout his life, for all that they are arguably highlighted one at the beginning, the other at the end. Yet this is counter to Bergson's own assertions concerning how he began each work with a clean slate, developing his ideas in isolation from those that had gone before.[69] I would argue that perhaps Bergson's understanding of the real, in later life, needed recourse to a notion of divinity in the absence of conceptual tools from scientific endeavour that could make such recourse unnecessary: the conceptual tools of complexity science. But for Kolakowski the questions of divinity highlighted in Bergson's last work are the most important point of it all, and the focus in his own treatment of all of Bergson's work. Indeed, he zeroes in on (and spends some time discussing) what he admits is 'the only sentence in *Creative Evolution* in which the word God appears':[70]

> God thus defined, has nothing of the already made; He is unceasing life, action, freedom. Creation, so conceived, is not a mystery; we experience it in ourselves when we act freely.[71]

Although Kolakowski says this is the only sentence where the word God appears in *Creative Evolution,* it does indeed, in Mitchell's translation at least, appear a great deal more frequently; but this is probably the only sentence where its use refers directly to a meaning for the *élan vital*; elsewhere it appears in discussion of the ideas of Aristotle or Plato, Descartes, Spinoza or Leibniz, and – arguably – it is in this context that the quote Kolakowski is so fond of could be understood: that, in contrast to the understandings of the great philosophers with whom Bergson takes issue, if one is to use the images of God and of Creation, then these images must be defined in the terms of the *élan vital,* and not as mysteries. Many Christian critics of *Creative Evolution* labelled Bergson a pantheist: if God is creativity then He is indistinguishable from His creation. For Kolakowski, however, it is the later letters that seem to count, in which Bergson, already moving toward the Catholicism that coloured his last work, attempts to counter such critics by suggesting that the free activity of God is the source of the *élan vital* – of all *élans.*

In the end, for Kolakowski the major criticism of Bergson – that he tried to be both Descartes and Schelling – is true: 'Starting with inner experience he discovered consciousness as an absolute creator and he made time its property; then he asserted it as a work of the divine artist. To have it both ways within the same discourse proved to be impossible.'[72] I believe this is in fact rather unfair, and derives more principally from Kolakowski's own leaning toward granting greater importance to Bergson's theological interests than perhaps they deserve. My own reading of Bergson is that he did not attempt a coherent 'system', or all-embracing philosophy – in which he could have it both ways, instead viewing the universe as unfinished, constantly changing and evolving, and thereby not susceptible to a complete understanding; he had foundational criticisms, furthermore, of both Descartes and Schelling. In such a context there are bound to be dissonances between aspects of an understanding put forward by one philosopher; as Bergson enjoined us, it is the collaborative work of many that is continually required, to evolve and amend and tease out a philosophy that is useful.

As Mullarkey points out, 'While *Two Sources of Morality and Religion* holds one key to understanding Bergson's work as a whole by pointing to the finally ethical orientation of his analyses of time, mind, evolutionary biology and relativity physics, the empirical matters contained therein are no less empirical for all that: neither they nor ethics are reduced to each other.'[73] It is in this spirit that this volume suggests the principal, early and more empirical works of Bergson's oeuvre put forward a series of philosophical ideas in keeping with, and which can further, those now being put forward by complexity theorists, as I shall elucidate in Chapter 5.

It is in this spirit, too, that the next major work of interest, in 1987, appeared: Gunter and Papanicolaou's *Bergson and Modern Thought,* focussing upon the consonance of Bergson's ideas with the implications of quantum theory – ideas which we will also save for now and come to in Chapter 5.

Frederick Burwick and Paul Douglas then put together an edited collection of excellent essays, in 1992, entitled, *The Crisis in Modernism: Bergson and the Vitalist Controversy*. This is arguably a classic in the revitalisation of interest in Bergson, exploring as it does so many different aspects of his legacy. Their own introduction and concluding chapter to the collection put forward the same incredulity as Kolakowski, Guerlac and Mullarkey with respect to the eclipsing of Bergson's thought following the Second World War, and suggesting – as I have argued with regard to Edman's commentary – that 'his work is a repressed content of modern thought.'[74]

The two essays in the collection of most interest to the current volume, however, are those of Maria de Issekutz Wolsky and Alexander Wolsky, whose essay on biology closely matches my evolutionary concerns, and Milič Čapek's essay on physics, which addresses some of the issues I will raise in Chapter 5.

The Wolskys suggest that Bergson's avoidance of taking sides between the microevolution of Darwin's gradualism, and the macroevolutionary jumps of many contemporary evolutionists of his day, preferring to suggest that both may be partly true, anticipates Gould's 'punctuated equilibrium.'[75] This is profoundly important for the argument of this volume, as we have seen both in the previous chapter and will see again in Chapter 5. Bergson's argument – as we saw – focuses on complex organs such as the eye, and how neither micro- nor macro- interpretations of evolution seemed capable of explaining how such complexity could originate; the eye indeed remains the focus of much research and attention to this day.

The Wolskys suggest that the *élan vital* could be interpreted today as information in the DNA-RNA-Protein machine of molecular biology[76] – a comment both rooted in its own historical context, when molecular biology was a rising star, and with poignant insight into the character of Bergson's ideas. The suggestion of this volume is that Bergson's *élan vital* could be interpreted today in terms of our current rising star, complexity. But the Wolskys make an important point here: they suggest that the historical context of Bergson's ideas, and the now dated examples he was concerned with, should not blind us to his insights: because he was addressing fundamental issues that are still current, and because he arguably 'called' several later developments in evolutionary theory long before they arose.

Milič Čapek, in his essay, focuses on the Mind–Body problem – from the perspective of modern physics. Čapek explores the suggestion that the organism, the basic unit of Darwinian evolution, could be interpreted as an amplifier of the kind of 'indetermination' that is observed at sub-atomic levels. There are plenty of contraptions science has put together to display otherwise unobservable processes – only to find that nature had already provided something very similar. Why not the organism itself? Čapek explores the break with 19th century mechanism in terms of its absolute causalism – the notion that the universe is entirely determined by fixed processes. The limits of causal description in atomic processes, discovered in the 20th century (which we will explore more in Chapter 5) broke this causalist world. Čapek describes this as microphysical indetermination. Čapek also addresses epiphenomenonalism, asserting that psychical interruptions and determinations of the physical universe do indeed occur, albeit not in Jordan's or in Elsasser's terms, but certainly in principle, as Bergson outlined. Indeed, 'the psychophysical interaction which remained an utter irrationality in the classical deterministic framework, ceased to be so in the genuinely growing and temporalistic universe whose most important features were foreseen by Bergson prior to its discovery by contemporary physics.'[77] Čapek's work is far broader and deeper than I have time here to address, but the core message seems to concern this confluence between Bergson's world of flux and that of quantum theory, and we will explore this further in Chapter 5.

Two other writers who have taken part in the revitalisation of interest in Bergson since the advent of poststructuralism are John Mullarkey and Keith Ansell Pearson, whose philosophical attention to the nuances and implications of Bergson's work have been key to the re-emergence of Bergson as a well-known and rated philosopher amongst contemporary philosophers. Indeed, as Mullarkey says in the introduction to his collection of essays, *The New Bergson*:

> with the emergence of such new areas as complexity theory and environmentalism, all the revitalisation of older issues concerning reductionism and materialism, there is probably no better time than now to progress from the usual strategy of gesturing towards the untapped fecundity of Bergson's ideas to a detailed examination of how they compare with work done by figures such as Stuart Kaufmann (complexity theory/ Philosophy of biology), Garrett Hardin (environmentalism) and Thomas Nagel (Philosophy of mind), to name but three.[78]

This volume is in some ways an attempt to undertake the first of Mullarkey's above suggestions. Mullarkey's concluding remarks, in his book *Bergson and Philosophy*, concerning Bergson's enjoining of philosophers to continually remake philosophy, are also of particular note with respect to the present volume: 'For Bergson,' he says, 'philosophy is not about discovering the right expression to represent reality, be that reality a process one or not: the absolute is not comprehended simply "by giving it a name". On the contrary, because logical essences themselves mutate, philosophy is about *creating* the right expression.'[79] It is in just this spirit that I reimagine the *élan vital*, in Chapter 5, as the explosively emergent self-organisation of ecological complexity, and although granting it a 'new name,' *creative emergence,* I do so in the spirit that it is a modification of the last one, and already ripe for further change: it is not the name, in other words, that counts.

There has, recently, beyond these few volumes I have picked out, been a raft of new scholarship on Bergson beyond the interests of this volume, including Kelly's (2010) *Bergson and Phenomenology*, Lefevre's new book (2013) *Human Rights as a Way of Life: On Bergson's Political Philosophy,* and Crocker's (2013) *Bergson and the Metaphysics of Media.* Additionally, though there has not been time nor space to include consideration of them in this volume, there is an important and significant strain of Bergson studies as represented by Manuel de Landa's Deleuzian *A New Philosophy of Society: Assemblage Theory and Social Complexity* (2006), Keith Ansell-Pearson's *Philosophy and the Adventure of the Virtual: Bergson and the Time of Life* (2002), Isabella Stenger's solo work since her collaborations with Ilya Prigogine – which I shall make great use of in Chapter 5 of this volume – and the work of Brian Massumi.

My argument here is not simply that Bergson is newly fashionable, and worthy of applying to just about anything – including complexity theory – but that his 'rediscovery' by so many, and across so many concerns, is an acknowledgement that one of the greatest philosophers of the past century has been given a rough ride: Santayana's 'trashing' of Bergson indeed, as Burwick and Douglass suggest, 'helped to fire a new mode of Western thought – one which required sacrificial figures.'[80] Bergson's most famous work, *Creative Evolution*, and the ideas that fed into it from his earlier books, expressed a 'science of life' that offers us a newly conscious interpretation of the life sciences that is capturing the attention of many, not because he understood what we know now, but because his understanding of what was known 100 years ago gave him insights which are proving extremely pertinent in light of what we do know now.

Furthermore, as I have made clear in this chapter, Bergson's ideas have had a powerful influence on the development of poststructuralist thought, and poststructuralist approaches have been put forward as a better means of understanding complexity than reductionist ones.[81] It is in this spirit that I must now turn to an exploration of systems theory, which will be our focus for the second half of this volume. In the next chapter, then, I will lay out a poststructuralist, genealogical history of systems theory up to the advent of complexity, showing how the reductionist mechanism of the 19th century persisted throughout the 20th century, and how – as Foucault himself would clearly have seen – the power relations between scientists, warring powers and the politicians leading them, and the ideas which gained traction in academic circles, kept those mechanistic theories afloat even in the face of empirical data completely refuting them.

Notes

1. Kolakowski, L. (1985) *Bergson* South Bend, IN: St Augustine's Press p. 1
2. *CE* p. xvi
3. Levi-Strauss, C. (1992). *Introduction to a science of mythology*. London: Penguin.
4. Kanaev, I. I. (Bakhtin, M. M.) (1992 [1926]) 'Contemporary Vitalism', trans. C. Byrd, in Burwick, F. and Douglass, P. eds. (1992). *The crisis in modernism: Bergson and the Vitalist Controversy*. Cambridge: Cambridge University Press p. 7
5. Spencer, H. (1860) *The Social Organism* http://www.econlib.org/library/LFBooks/Spencer/spnMvS9.html
6. Galton, F. (1904) Eugenics: Its Definition, Scope, And Aims, *The American Journal Of Sociology* X(1)
7. Searle, G. R. (1976) *Eugenics and Politics in Britain, 1900–1914* Kluwer Academic Publications http://books.google.co.uk/books?id=M7bpqZp3yiMC&printsec=frontcover#v=onepage&q&f=false

8. United States Holocaust Memorial Museum, *The Biological State: Nazi Racial Hygiene, 1933–1939* http://www.ushmm.org/wlc/en/article.php?ModuleId=10007057
9. Watkin, E. I. (1938) The Nazi Philosophy of Life *The Tablet: International Catholic News Weekly* 27th August 1938, p. 5 http://archive.thetablet.co.uk/article/27th-august-1938/5/the-nazi-philosophy-of-life
10. Burwick, F. and Douglass, P. eds. (1992). *The crisis in modernism: Bergson and the Vitalist Controversy*. Cambridge: Cambridge University Press. p. 7
11. Russell, Bertrand (1977). *The philosophy of Bergson*. Folcroft, PA: Folcroft Library Editions.
12. Santayana, G. (1913) Winds of Doctrine, London: J. M. Dent https://ia600308.us.archive.org/21/items/windofdoctrine00santuoft/windofdoctrine00santuoft.pdf
13. Burwick, F. and Douglass, P. eds. (1992). *The crisis in modernism: Bergson and the Vitalist Controversy*. Cambridge: Cambridge University Press. p. 7
14. *CE* p. 48 footnote
15. Mayr, E. (2002) Walter Arndt Lecture: The Autonomy of Biology http://www.biologie.uni-hamburg.de/b-online/e01_2/autonomy.htm
16. Ibid.
17. *CE* p. 48
18. *CE* pp. 48–49
19. *CE* p. 50
20. Burwick, F. and Douglass, P. eds. (1992). *The crisis in modernism: Bergson and the Vitalist Controversy*. Cambridge: Cambridge University Press. p. 4
21. Kolakowski, L. (1985) *Bergson* South Bend, IN: St Augustine's Press p. 102
22. Kelly, M. (ed) (2010) *Bergson and Phenomenology* London and New York: Palgrave
23. Mullarkey, J. (ed) (1999) *The New Bergson* Manchester: Manchester University Press p. 2
24. Deleuze, G. (1991[1966]) *Bergsonism*. New York: Zone Books. p. 7
25. Burwick, F. and Douglass, P. eds. (1992). *The crisis in modernism: Bergson and the Vitalist Controversy*. Cambridge: Cambridge University Press. p.379
26. Deleuze, G. (1991[1966]) *Bergsonism*. New York: Zone Books. p. 13
27. Ibid. p. 15
28. Ibid. p. 17
29. Ibid. p. 21
30. Ibid. p. 29
31. Ibid. p. 31
32. Ibid. p. 16
33. Ibid. p. 17
34. Ibid. p. 17
35. Ibid. p. 22
36. Ibid. p. 29
37. Levi-Strauss, C. (1963) Structural Anthropology. New York: Basic Books
38. Barthes, R (1967) *Death of the Author*. Aspen 5–6 (3) http://www.ubu.com/aspen/aspen5and6/threeEssays.html#barthes
39. Althusser, L. (1968) *Reading Capital*. Paris: Maspero. http://www.marx2mao.com/Other/RC68NB.html
40. Lacan, J. (1968) *The Language of the Self: The Function of Language in Psychoanalysis*. Baltimore: Johns Hopkins University Press.

41. Deleuze, G. (1983) *Plato and the Simulacrum*. trans. Krauss, R. *October* 27, pp. 45–56
Deleuze, G. and F. Guattari (1987). *A thousand plateaus: capitalism and schizophrenia*. Minneapolis: University of Minnesota Press
Deleuze, G. (1990) *Logic of Sense*. trans. Lester, M. & Stivale, C. London and New York: Columbia Uni Press
Deleuze, G (1995) *Difference and Repetition*. trans. Patton, P. London and New York: Columbia Uni Press
42. Foucault, M. (1977). *Discipline and Punish*. London: Penguin
Foucault, M. (1994). *The Birth of the Clinic: an archaeology of medical perception*. New York: Vintage Books
Foucault, M. (1995a). *The Archaeology of Knowledge*. London: Routledge
Foucault, M. (1995b). *Madness and Civilization: a history of insanity in the age of reason*. London: Routledge
Foucault, M. (1997). *The Order of Things*. London: Routledge
Foucault, M. (1998) *The History of Sexuality: The Will to Knowledge*. London: Penguin
43. Derrida, J. (1974) *On Grammatology*. trans. Spivak G. C., Baltimore: John Hopkins University Press
44. Butler, J. (1990). *Gender Trouble*. London: Routledge
Butler, J. (1993). *Bodies That Matter*. London: Routledge
Butler, J. (1997). *Excitable Speech*. London: Routledge
45. Irigaray, L. (1993 [1984]) *An Ethics of Sexual Difference*. Cornell University Press
46. Kristeva, J. (1982) *Powers of Horror: An Essay on Abjection*. New York: Columbia University Press
47. Williams, G. (1999) *French Discourse Analysis: The method of Post-Structuralism*. London: Routledge
48. See Kreps, D. (2010) My Social Networking Profile: Copy, Resemblance or Simulacrum; A Poststructuralist Interpretation of Social Information Systems. *European Journal of Information Systems*, 19(1) for an explication of this argument.
49. Gadet, F. (1987) *Saussure*. London: Heinemann p. 30
50. Williams, G. (1999) *French Discourse Analysis: The method of Post-Structuralism*. London: Routledge p. 37
51. *CE* pp. 174–175
52. Williams, G. (1999) *French Discourse Analysis: The method of Post-Structuralism*. London: Routledge pp. 44–48
53. Ibid. pp. 71–74
54. Ibid. pp. 78–79
55. Ibid. pp. 78–79
56. Cilliers, P. (1998) *Complexity and Postmodernism* London: Routledge p. 43
57. Williams, G (1999) *French Discourse Analysis: The method of Post-Structuralism*. London: Routledge. pp. 78–79
58. Foucault, M. (1990). *History of Sexuality Vol 3: The Care of the Self*, London: Penguin
59. Foucault, M. (1988) (eds. Martin, L, Guttman, H, and Hutton, P) *Technologies of the Self*. Amherst, MA: University of Massachusetts Press
60. Burwick, F. and Douglass, P. eds. (1992). *The crisis in modernism: Bergson and the Vitalist Controversy*. Cambridge: Cambridge University Press p. 379

61. Ibid. p. 379
62. Ibid. p. 379
63. Butler, J. (1993) *Bodies That Matter* London: Routledge p. 10
64. Ibid. p. 10
65. Deleuze, G. (1991[1966]) *Bergsonism*. New York: Zone Books p. 98
66. Kolakowski, L. (1985) *Bergson* South Bend, IN: St Augustine's Press
67. Ibid. p. 53
68. Ibid. p. 54
69. Mullarkey, J. (1999) *Bergson and Philosophy* Indiana: University of Notre Dame Press p. 5
70. Ibid. p. 61
71. *CE* p. 271
72. Kolakowski, L. (1985) *Bergson* South Bend, IN: St Augustine's Press p. 105
73. Mullarkey, J (1999) *Bergson and Philosophy* University of Notre Dame Press p3
74. Burwick, F. and Douglass, P. eds. (1992). *The crisis in modernism: Bergson and the Vitalist Controversy*. Cambridge: Cambridge University Press. p. 7
75. Ibid. p. 160
76. Ibid. p. 165
77. Ibid. p. 188
78. Mullarkey, J. (ed) (1999) *The New Bergson* Manchester: Manchester University Press p. 2
79. Mullarkey, J. (1999) *Bergson and Philosophy* Notre Dame, IN: University of Notre Dame Press p. 185
80. Burwick, F. and Douglass, P. eds. (1992). *The crisis in modernism: Bergson and the Vitalist Controversy*. Cambridge: Cambridge University Press p. 2
81. Cilliers, P. (1998) *Complexity and Postmodernism* New York: Routledge

4
Systems Theory Grows Up

The concept of a 'system' is an old one: etymologically it derives from the Greek *sustēma*, from *sun-* 'with' and *histanai* 'set up,' meaning uniting, putting together. But the scientific use of the term is relatively recent; perhaps Carnot was the first to use the term scientifically, when describing the behaviour of steam in his pioneering study of thermodynamics in the 1820s.[1] In this chapter, in keeping with the growing poststructuralist flavour of the last, and as a bridge from the focus upon Bergson to the focus upon complex systems, I will present a somewhat Foucauldian genealogical interpretation of the concept of 'system', using material from as far back as the early 19th century, but concentrating mainly on the use of the term during the 20th century, and what it has bequeathed to us today. In the next chapter, I will consider Bergson's ideas in conjunction with the contemporary science of 'complex systems', or 'complexity' as it is often referred to. The current chapter will seek to look at the development of 'systems' thinking prior, and up to, 'complex systems.'

'System', as a concept in modern thought, as with any genealogical interpretation of something contemporary, turns out to have multiple and varied sources, each of which were themselves interpretations. Most importantly, Carnot aside, in this reading, the understanding of and concentration upon the notion of 'ecosystem,' in the early 20th century, seems to predate such a strong focus upon the notion of 'system' in general. Evolutionary science, and biology, in other words, were at the very least influential in the creation of our concept of 'systems'.

I will first make some remarks on the nature of the genealogical approach.

On genealogy

Genealogical interpretation was most famously introduced to critical theory and philosophy by Michel Foucault, who derived it largely from Friedrich Nietzsche.[2] A literal translation of the word would be an account (logos) of the genesis of a thing. Nietzsche uses the concept for his attack on Christian morality, finding particularly in the writer, Tertullian, evidence that the unalloyed 'will to power' of the noble warrior-Romans had been overcome by the Jewish, and then Christian reification of weakness. Christian morality, for Nietzsche, is made up of all the resentments and spite that weakness entails. This critical approach to understanding contemporary issues, through a form of conceptual historical analysis, Foucault turned into a method.[3] A genealogy, for Foucault, be it of values, morals, or knowledge, does not concern itself with historical development on the model of the idea of progress, and must never confuse itself with a quest for 'origins'. To pursue origins, is by contrast a pursuit of essence, and as Foucault reminds us, 'he who listens to history finds that things have no pre-existing essence,'[4] no lofty, 'before the Fall' beginning, but rather a proliferation of errors, accidents, events, oppositions: in short, a dispersed and multiple set of contingencies upon which custom, practice and power build something that mainstream history comes to regard as a truth. There are, indeed, echoes here of Bergson's critique of the notion of progress in the approach of finalism, just as there are of his critique of mechanism and rationalism and its own notion of the progress of science ever nearer to the 'facts' and to the 'truth'. Echoes, too, there are of the divergence of the sheaf of evolution in Bergson's ideas, where blind alleys, 'deviations, arrests, and set-backs, are multiplied.'[5] It has even been suggested that what Bergson offered us was ultimately a 'genealogy of consciousness.'[6]

Similarly, the development of systems theory is not something that began with some 'original' idea – such as Carnot's, since built upon by successive theorists towards today's complex understanding – but rather it is a collection of intimations, influences, and turns: a series of differing interpretations, from diverse and previously unrelated sources. In choosing a title for this chapter then, *Systems Theory Grows Up* is meant, not to suggest that modern systems theory has grown like a tree from previous theories, but to convey something of the flavour of how, in general, today's understanding of complex systems is simply more mature, and has shed some of the more 'childish' and simplistic metanarratives of earlier systems theories, and learnt more about how little we know.

The role of this genealogy is thus to attempt to present to the reader 20th century systems thought in its immaturity. Foucault's historical analysis is one that deals with the history of thought, of knowledge, of philosophy, of literature, but – going further than Bergson's own 'history of systems' in the latter part of *Creative Evolution* – Foucault's genealogy, as an analysis, attempts to step back, in a kind of double detachment, from claims both of truth and deep meaning in history, and to study the discourse of any particular time with a neutrality as to whether what it asserts is true, makes sense, or even, 'whether the notion of a context-free truth claim is coherent.'[7] Undertaking, then, a genealogical interpretation of 'systems theory,' with this detached form of historical analysis, I can adopt a perspective that is not tied to the needs of a suggestion that contemporary complexity is the culmination and truer outcome – the adult version – of what could be viewed as a terrible series of previous mistakes. Complexity, indeed, in this form of analysis, is but the latest interpretation of the meaning of the notion of 'system'. A child may grow into an unruly, foolish adult just as much as a more 'noble' one.

In some respects, then, Foucault's genealogical approach seems influenced by Bergson, whose own 'genealogy' of evolutionary thought in *Creative Evolution* picks out the errors in some of the greatest philosophers of the previous two millennia. In other respects Foucault takes things much further than Bergson, stepping beyond any attempt at 'truth,' beyond a wish to suggest that modernity (let alone postmodernity) offers anything intrinsically better than previous eras. Indeed in Foucault one can often find, behind the sharp critique of the Enlightenment, an orientalist yearning for a non-European 'other' world, an escape from the confines of his milieu.[8] From this perspective we may examine the concept of 'system', in this chapter, without the feeling that Bergson's ideas – or his critique – need necessarily be found there; that the complex systems notion where in Chapter 5 we shall find confluences with Bergson's ideas contains them because they were there in some essence from the start. To the extent that complex systems theory looks beyond the mechanistic, reductionist approach of much systems theory, it chimes with Bergson's critique of the 19th century approach. That is all. Systems theory, in its 20th century form, was conceived and developed in the mindset which Bergson critiqued, and which consigned Bergson to the backwaters of history, from which he has only recently returned.

For anyone who has never stopped to question what the word 'system' might mean, then, this genealogical interpretation will be both revealing and, at times, disturbing.

Concerning metaphilosophy and root metaphors

Despite the multiple, diverse, and oppositional sources of knowledge described above, patterns can be – and often are – discerned by those undertaking genealogical analysis. Whether closer to Foucault's own epistemes – which gather all the various discursive formations and practices he describes into historic periods constituted by their own interrelationships, or Kuhn's paradigms – that mark periods of settled progress between upheavals (scientific revolutions as he described them), such periodic patterns, or themes, have been described by many critical theorists and philosophers. But such patterns may also be genres of sources and ideas, rather than historic periods. In this genealogy of systems theory I will be borrowing some terms and ideas from a philosopher 20 or 30 years previous to Foucault, namely Stephen Pepper,[9] whose approach was to categorise various philosophical ideas about the world according to what he described as the 'root metaphors' to which they adhered.

Pepper has been placed in the first generation of those one might describe as 'metaphilosophers', with Foucault amongst the second.[10] Metaphilosophers, according to Marcotte, advance 'a position *with regard to* philosophy, rather than a philosophical position per se.'[11] If philosophy is an undertaking to 'get to the bottom of things,' then with metaphilosophy it is '*philosophy itself*' which one is trying to 'get to the bottom of'.[12] Derrida, another of the second generation, along with Foucault, is explicit about this, in *Positions,* asserting that, 'metaphysics has always consisted in attempting to uproot the presence of meaning, in whatever guise, from *différance*.'[13]

Not adopting Pepper's 'philosophy' then, but borrowing his metaphilosophical schema as a lens to bring an interesting perspective – one that will help us to get to the bottom of what systems theorists are about – I will make use of some of Pepper's terms and ideas, to paint potential 'themes' by which some of this genealogical material concerning systems may be gathered together, and made coherent for the reader.

Specifically, Pepper writes, 'Among the variety of objects which we find in the world are hypotheses about the world itself.'[14] These fall into a series of categories, which Pepper identifies as 'root metaphors'. Having dispensed with what he describes as the myth of pure objective fact, and thereby the prevailing logical positivism of his era, and then with two 'inadequate' views (*animism* and *mysticism*), Pepper goes on to identify four 'basically adequate' world views, or conceptual systems – world hypotheses, as he calls them: *formism, mechanism, contextualism*, and *organicism*. As with Foucault's description of statements, and how the status of the speaker constitutes the efficacy of what is said,[15] Pepper stresses that there are certain criteria as to what constitutes 'evidence', and thus rules governing how we know what we know. Depending on your choice of 'root metaphor', different criteria exist as to what constitutes good evidence. This is not so much a relativist position as one that eschews a dogmatic approach toward one particular position against all others. As Pepper writes, 'Our postrational eclecticism is simply the recognition of the equal or nearly equal adequacy of a number of world theories and a recommendation that we do not fall into the dogmatism of neglecting any one of them.'[16]

i. For *formism* one can turn for no better description than to Plato's theory of forms: everything is explainable because it belongs to a particular category or form that has identifiable characteristic qualities. The primary philosophers are Plato, Socrates, and the Scholastics. This approach was the focus of Bergson's critique in the latter part of *Creative Evolution*. The root metaphor is that of analogy or similarity.
ii. For *mechanism* one has the example of reductionist science: everything follows the laws of cause and effect. The primary philosophers are Locke, Berkeley, Hume, Descartes, Hobbes, Russell. This approach was the target of Bergson's more general critique. The root metaphor is that of the machine.
iii. For *contextualism* one finds oneself embedded in the world of contingency: everything is connected to everything else and situated within a cultural milieu. The primary philosophers are Pierce, James, Dewey, Bergson himself, and Mead. The root metaphor is that of a historic event.
iv. For *organicism* one is in the world of organic wholes – a holistic world of living totalities. The primary philosophers are Hegel, Bradley, and Whitehead. The root metaphor is that of organism or coherence.

Many of the poststructuralist philosophers after Pepper's time – Foucault, Derrida, Deleuze – could be regarded as belonging to the *contextualist* category, like Bergson, whilst at the same time being metaphilosophers in their own right. *Organicism* might best be attributed to the 1970s – Lovelock and his Gaia Hypothesis[17] (albeit perhaps in a rather mechanistic vein). However, this too has undergone something of a metamorphosis, through the work of Goodwin[18] and others, who have reimagined *organicism* in the face of the *mechanistic* reduction of living wholes to the level of the selfish gene,[19] (of which more in the next chapter).

Although there could be endless debate about these terms, whilst not each constituting in themselves a philosophy, they do, for my current purposes, nonetheless adequately describe classes of philosophies, categories of approach, and will prove useful in the genealogical analysis of the notion of systems. Writing in the 1940s, Pepper's categories of course omit those philosophers and theorists that followed him, but whom – as Marcotte asserts – continued his tendency to metaphilosophise, albeit in their own ways, yet not without a number of things in common. Indeed, 'A commonality – not to say a strict equivalence – runs from Collingwood's 'presuppositions,' to Kuhn's 'paradigms,' to Foucault's '*epistemes*,' to Pepper's 'root metaphors,' to Wittgenstein's 'grammar,'[20] and this commonality is all that I wish to align myself with, rather than any specific position in itself.

In this spirit, then, I will be adopting elements of Foucault's genealogical approach to undertake a historical analysis of the notion of systems, and will be using Pepper's metaphilosophical categories as an additional lens, whilst at the same time not nailing my colours to the mast with regard to any of these approaches.

Considering the discursive formations of ecosystems and systems theory

The detail of Foucault's approach to genealogy is as follows: once, from its various multiple sources, a value, moral, or aspect of knowledge has been taken up in the conversation that constitutes the world of discourse, it becomes what he terms a discursive formation. It is then subject to what he describes as a series of 'rules of transformation'.[21] There are four thresholds such a discursive formation might pass over as it emerges, which he identifies as:

i. *positivity*, the moment when a discursive practice becomes recognisably distinct;
ii. *epistemologisation*, when the formation sets itself up with a group of statements against which others are to be judged true or false, and 'exercises a dominant function (as a model, a critique, or a verification) over knowledge',[22]

iii. *scientificity*, when such an 'epistemological figure' complies with 'certain laws for the construction of propositions,'[23] and
iv. *formalisation*, when it can take 'itself as a starting point, to deploy the formal edifice that it constitutes,'[24] defining everything it needs for its own existence.

The notion of systems has passed through the first three stages over the past two centuries. Although the boundaries between each stage are far from distinct, we will take them, roughly, in turn. There are two main strands to the story. The first strand concerns ecosystems: to begin with, in the *positivity* phase there was the development of the notion of ecosystems, from Darwin's 'entangled bank' in his 1859 classic *The Origin of Species*[25] (although the term itself was yet to be coined); then the *epistemologisation* of ecology as a discipline, along with Tansley's first coining of the term 'ecosystem' in his paper criticising Clements' holism in 1935.[26] This was followed by the *scientificity* phase through which Hutchinson[27] and his protégés (not least Lindeman[28]) mathematicised ecology during and after the Second World War. Parallel with this development, I must also call attention to the sociological and political thinking around the notion of ecosystem, including Spencer's influential paper *The Social Organism*[29] in 1860, which established the *positivity* of ecosystemic thought in sociological circles, and Jan Smuts' 1926 book *Holism and Evolution*[30] (the basic holistic premise of which was adopted by Clements[31]), which contributed to its *epistemologisation* as social Darwinism; *scientificity* eluded this element of ecosystems thought, although one branch of the ecosystem-influenced humanities, economics, made great attempts to achieve *scientificity,* as described below.

The second strand of this history is the rise of systems theory itself, beginning with the first scientific use of the term 'system', in Carnot's work in the 1820s, which entered scientific discourse around thermodynamics in the 1850s. The next major development of the use of the term, however, came with the importation of the nascent *positivity* of ecosystems by the biologist Bertalanffy[32] into his (1933) *Modern Theories of Development,* with which he attempted an *epistemologisation* of the notion of 'systems'. This, through the enormous reorganisation and redirection of scientific research in the US during the Second World War, took on *scientificity* with the mathematics and influence of John von Neumann, and the development of Operations Research and Information Theory as part of the war effort, and aimed for *formalisation* with Norbert Wiener and others' late 1940s and early 1950s work on cybernetics. Bertalanffy's

(1950) *Theory of Open Systems in Physics and Biology*[33] and (1968) *General Systems Theory*[34], and Laszlo's (1972) *Introduction to Systems Philosophy*[35], sought to entrench this attempt at *formalisation* in every sphere of knowledge. Indeed, the very nature of the 'systems thinking' approach of these scientists meant that systems theory, at least from the 1940s, was a proselytising faith, seeking to subsume as many walks of scientific life within its reach as possible, offering a unified theory to connect and contain them all – an attempt at *formalisation par excellence*.

Nevertheless, neither ecosystems nor systems theory were successful in achieving *formalisation* – as Laszlo acknowledges in his later *Systems View of the World*.[36] For Foucault, it is perhaps only mathematics that has achieved this, and, uniquely, crossed the thresholds of *positivity, epistemologisation, scientificity* and *formalisation* all at once.[37] For the economist Mirowski, it seems physics managed – albeit perhaps only politically – to achieve *formalisation* in the manner in which all other scientific – and indeed humanistic – pursuits were arranged in its image and in its shadow, for several decades of the 20th century. Today, one might say, it is biology that is aiming for this *formalisation,* not least through the spread of the notions of complex systems out of environmental biology into, not just other areas of science, but, as with the present volume, into the humanities. For Laszlo, it indeed offers a Theory of Everything.[38]

There are two ways that this complex story of two strands – ecosystems and systems theory – could be told: firstly in a chronological manner, either chronologically across both, or chronologically in two separate tales. The latter has been done: Hagen's *Entangled Bank*[39] and Golley's *Ecosystem Concept in Ecology*[40] on the history of and problems with ecosystems ecology – though without much on systems theory; Lilienfeld on the *Rise of Systems Theory*[41] – though without the new perspective of complexity and only up to 1978; and Mirowski's *Machine Dreams*[42] on John von Neumann and the rise of physics, and economics as a cyborg science, though without the notion of ecosystems. There is also much useful material for this tale in the work of Belgian physical chemist Ilya Prigogine, especially his book with Isabella Stengers, *Order out of Chaos*.[43] Only Alan Curtis has tried to tell some of all this together, in his *Rise of the Machines*[44] documentary series and accompanying *Observer* article,[45] adding the story of Ayn Rand and her reification of the selfish individual.

A second way in which these complex interlinking stories can be told, however, would be to critique the failings of both ecosystems and systems theory as they have been presented up to the present day, thematically. Linking all these stories together, then – showing how each element, as a *discursive formation*, unfolded through Foucault's 'rules of transformation,' and exposing their flaws – is my task for this chapter.

Within the Foucauldian method, the 'book' or 'paper,' or the '*oeuvre*' of particular thinkers, by which we have thus far characterised the two strands of systems thinking that are our focus in this chapter, dissolve into a far more rarefied field, or domain of discursive practices. That this or that author, working in this or that department of this or that university or commercial laboratory, may, in the average narrative in the history of ideas (such as those of Hagen, Golley, Lilienfeld, Prigogine and Stengers, and Mirowski), be 'credited' with this or that idea, along the path from before such a discipline has formed, to its contemporary formation, is neither the point nor the methodology of understanding that Foucault proposed. The discursive formations of ecosystems ecology and systems theory are, in any case, far from discrete disciplines, whose elements can be found exclusively in the writings of those considered their principal proponents. For those readers who have come across Mirowski's *Machine Dreams,* it will already be clear that the mathematician John von Neumann – who never published a single book or paper on ecology, or, indeed, economics – had a profound influence on both. Yet his contribution must itself be seen as deeply contextualised within the shifts and changes of both the discursive formation of mathematics, and the political and social changes of the Second World and Cold Wars. It will also be clear from the discussion above that (Carnot aside), the notion of ecosystem preceded and, through the biologist Bertalanffy, heavily influenced the development of systems theory. That both can be seen as instances of Pepper's guiding 'root metaphor' of *organicism*, openly proposed by Spencer in 1860, yet far older in origin, I will presently elaborate upon. Foucault's method invites us to understand these discursive formations – and the *oeuvres* which run through and between them – as discursive practices to which individuals, apparatuses, contexts and rivalries belong, and not the other way around: these formations are discourses with their own internal rules, and in every authoritative statement that shapes them we must see how authority has been conferred upon s/he who makes the statement by the internal logic of the discourse itself.

Positivity

I will begin with Charles Darwin, not only because, as I stated at the outset, this is a book about evolution, but because our understanding of the notion of 'system' has been crucial to our understanding of the concept of evolution (and, indeed, vice versa).

In his concluding remarks to *On The Origin of Species,* Darwin waxes lyrical on the grander scheme of life:

> As all the living forms of life are the lineal descendants of those which lived long before the Silurian epoch, we may feel certain that the ordinary succession by generation has never once been broken, and that no cataclysm has desolated the whole world. Hence we may look with some confidence to a secure future of equally inappreciable length. And as natural selection works solely by and for the good of each being, all corporeal and mental endowments will tend to progress towards perfection.
>
> It is interesting to contemplate an entangled bank, clothed with many plants of many kinds, with birds singing on the bushes, with various insects flitting about, and with worms crawling through the damp earth, and to reflect that these elaborately constructed forms, so different from each other, and dependent on each other in so complex a manner, have all been produced by laws acting around us.[46]

Quite apart from the more contemporary understanding that cataclysms have indeed beset life on earth on a number of occasions (and our current predicament could be said to constitute another), these summary remarks display Darwin's much commented-upon[47] combination of two contradictory views: his default position within the stable, natural and lawful order of *gradualist* slow progress; alongside his revolutionary idea of the cut-throat competition of natural selection.

The stronger of these views seems to be the general belief that the great span of life's history and 'progress towards perfection', and the 'entangled bank' by his walk near to Down House in Kent, where he wrote his book, are representative of a stability and an equilibrium in nature – of a natural order in which all things are, in the end, at rest. As Hagen notes, however, 'despite his confidence that the struggle for existence could explain natural order, Darwin did not rigorously do so in 1859.'[48] These were literary additions to his more 'technical discussion of speciation and the evolution of adaptations.' The idea that the 'survival of the fittest' somehow created both the bucolic idyll of the entangled bank and the great stability of life through history (as Darwin saw them) was left, in fact, to 20th century biologists to try to work out.

This image of a natural order that purveyed both the history of life on earth and of its outcomes – such as that of the 'entangled bank' – is one that can be viewed in the context of the wider currents of the early 19th century. As we saw in Chapter 2, one of Darwin's most powerful influences was of course Jean-Baptiste Lamarck (1744–1829), protégé of the Comte de Buffon (1707–1788), who had made one of the earliest suggestions that living things do change over time, albeit with the later discredited notion of the inheritance of acquired characteristics. Lamarck's work on the processes of biological change is regarded as having first defined the new science of biology, and constituted one of the first theoretical frameworks of organic evolution. But, of the wider currents of intellectual life in the early 19th century, influencing Darwin's thought, perhaps more pertinent – certainly for the purposes of this chapter – are those concerning the flowering of classical dynamics, the early elaboration of the principles of geology, and the ideas of the Scottish Enlightenment.

The subtle but pervasive influence of the rise of classical dynamics and mechanics in everyday 19th century society – which Bergson was to focus his critique upon at its end – bears close consideration. Newtonian science, in many ways, arose from looking at the sky. Kepler's laws for planetary motion, Galileo's laws for falling bodies, and Newton's (and Leibniz's) mathematical innovation, differential calculus – used by him to calculate the motions of the moon – and his famous new understanding of planetary gravity, all came together to create Newton's Laws of Motion. The Laws of Motion – and Lagrange's later development of them – were a focus on forces and dynamics, on acceleration and deceleration, and the calculability of those forces on various points. Perhaps key to these Laws, as the 19th century unfolded, was a more general philosophical standpoint, epitomised by Laplace (1749–1827) and his famous demon.

Laplace imagined a demon sitting on the scientist's shoulder (although it was others, later, who called it that) which could (unlike us) see the actual initial conditions of any process, and would therefore be 'capable at any given instant of observing the position and velocity of each mass that forms part of the universe and of inferring its evolution, both toward the past and toward the future.'[49] The entire universe, and everything in it, in this view, was completely determined by simple, clear, scientific laws, deep into the past and far into the future. The fiction of the demon was Laplace's reasoning for the need, in many situations, nonetheless to use statistics and probabilities – on which he wrote many of the most important texts of the early 19th century – to describe and understand the processes involved. It was a fiction that asserted that deterministic *laws* govern all things, and that our ignorance of initial states sometimes makes such deterministic predictions impossible. But this ignorance must be distinguished from 'the "objective truth" of the system as it would be seen by Laplace's demon'.[50] Thus, for Laplace, probability and chance relates to our (necessarily limited) knowledge of things and not to *things in themselves*. This 'Laplacian view of chance is the one which Darwin consistently held.'[51]

These Laws attained, in 1830, their supreme *scientificity* with what came to be known as the Hamiltonian. Irish physicist William Rowan Hamilton (1805–1865), a prodigy granted a full professorship whilst still an undergraduate, granted to Newtonian/Lagrangian classical dynamics a coherence it had not yet quite achieved, enabling all the various aspects of dynamics to be 'summarised in a single function, the Hamiltonian'.[52] The calculations of energy, motion, velocity and other variables were, until this time, simple to calculate for a body falling to earth, but more complex when there were interacting bodies. But Hamilton's function (H) sums up all the total energy, the sum of potential and kinetic energy, enabling swifter and clearer calculations. Once the function (H) is known, in principle all possible problems are solvable. 'This Hamiltonian formulation of dynamics,' enthuses Prigogine, 'is one of the greatest achievements in the history of science.'[53]

A world characterised by such trajectories, by 'lawfulness [and] determinism'[54] emerged in the 18th and early 19th century, which has been with us, only barely modified, up to the present day. These laws concentrated on the change from rest to motion, from motion to rest, and all changes in velocity. As we have seen, these changes, motions, and velocities, were, in Bergson's terms, all represented spatially – geometrically – and the real time of duration was discounted. Prigogine describes in his history of these developments how, once these laws are accepted, then, 'At each instant…everything is given. Dynamics defines all states as equivalent: each of them allows all the others to be calculated along with the trajectory which connects all states, be they in the past or the future…. Everything is given, but everything is also possible.'[55] Importantly, 'The *reversibility* of a dynamic trajectory was explicitly stated by all the founders of dynamics.'[56] Laplace, indeed, had asserted that his demon could see both into the past and into the future. Despite some arguments to the contrary, over the succeeding years, 'by the early 19th century the Newtonian program – the reduction of all physiochemical phenomena to the action of forces –…had become the official program of Laplace's school, which dominated the scientific world at the time when Napoleon dominated Europe.'[57]

Reductionism *per se* is, perhaps, ultimately what is at issue here. To assert that one scientific theory, or one philosophy, is preferable to another if it requires fewer different kinds of objects in order to explain reality is a dream epitomised by William of Ockham, the 14th century English philosopher, who first suggested the principle that entities should not be multiplied beyond what is necessary – Ockham's famous 'razor'. Whilst for pragmatic purposes this may indeed be a very useful approach to life, it nonetheless flies in the face of the very evident multiplicity and continual difference we find in the world around us – the very absence of such simplicity. Indeed, as we shall see in the next chapter, in the quantum uncertainties of the subatomic, it is apparent that the world is not simple: that viewing things from one angle prevents understanding of one parameter, and from another angle another parameter, such that only multiple understandings are possible, each with educated guesses and statistical probabilities with which to dress the unknown. The philosophical analyst who discovers that A can be just as well analysed in terms of B, as B can in terms of A, sits himself upon Ockham's razor to ponder which one to reduce himself to: a painful end to the project of reductionism. But for Hobbes all things could be reduced to the material, and for Newton all things could be reduced to forces: to dynamics.

The focus of solving the problems of classical dynamics shifted, after Isaac Newton (1642–1727), from Britain to France and elsewhere. In Britain it was the application of this science by engineers that then captured the minds and funds of society. Newton's classical dynamics, newly emboldened in the late 18th century by its refinement by French mathematician Louis Lagrange (1736–1813), and in the early 19th by the Hamiltonian, enabled in British workshops the engineering of complicated machines, which in the first half of the 19th century was already producing extraordinary new inventions. Bicycles (1817), and bicycles with pedals (1839),[58] paddle steamships (1839),[59] sewing machines (1846),[60] and Bessemer's new process for the making of steel (1855)[61] – which helped to revolutionise railway and bridge building – had all been invented before Darwin published his *Origin* in 1859. Prior to his voyage upon HMS Beagle, Darwin had been profoundly influenced by (among others) the astronomer Herschel's book, *A preliminary discourse on the study of natural philosophy,* and its description of nature as being governed by laws which, although difficult to discern or to state mathematically, should nonetheless be the highest aim of natural philosophy to discern.[62] The idea that all things could be worked out – that the neat equations of classical dynamics could find their equivalents in all fields of scientific endeavour, and that that scientific endeavour should be to describe life, the universe, and everything in such terms – held a powerful influence over all academic and practical pursuits, including biology. It was, indeed, a very brave man indeed who challenged the foundations of this; and, at the end of the century, Bergson's work earned fierce criticism from those who clung to it, as well as high praise from those who found it stifling.

The new science of biology, however, was influenced by more than the pervasive presence of classical dynamics. Geology, too, made its mark. Geology was a very new science, like biology, with profound implications for the Western mindset, and a major challenge to foundational views held across Europe and North America about the origin of life and the age of the Earth. The notion of Creation was still strong. The gradual re-emergence of Hellenistic scientific thought from theological dogma, begun in the mid 16th century in Europe with the likes of Copernicus, slow at first, was by the late 18th century gathering pace. The empirical scientific method gradually took precedence over the classical texts of the Scholastics. Descartes (1596–1650), as we saw in Chapter 2, had sliced the universe in two – setting the world of thought and theology on one side as 'unknowables', with the ordered and lawful world of science on the other, susceptible to experiment and, within a few decades, to Newton's Laws of Motion. This divide allowed the majority of lively minds to concentrate exclusively on science, and leave theology to the parish priest. Immanuel Kant (1724–1804) sealed the door, in effect, when pronouncing that, as the existence of God could never be proven empirically only reason could guide us morally. By the early 19th century mathematicians such as Charles Babbage (1791–1871) and the broader 'uniformitarian' movement had placed the notion of God very firmly in the position of divine legislator: laws set at the time of the Creation were all that were required to make the universe, which would then progress and continue to unfold gradually according to those laws – uniformly across the universe and down through time. In biology John Ray's early 17th century structure of genus and species was taken up and expanded into the taxonomy of Swedish botanist, Carolus Linnaeus (1707–1778), who gathered all flora and fauna into clear and carefully worked out categories, designed to reveal the unchanging order of life created, at the beginning, by God. Such notions, of divinely created lawful order and permanence, still held a powerful grip on the nascent biological imagination.

The great expanse of time during which this unfolding can have taken place, moreover, was still restricted by contemporary understandings of the age of the earth. Most scientists were yet to reach 'the acceptance of a terrestrial age significantly greater than the historical record of humankind (the notion, however vague, of "deep time").'[63] But the notion of such deep, or 'geological time'[64] – that the earth had been formed by a succession of events rather than a single act of creation – had been gaining popularity amongst a select group of geologists since the late 18th century; and, by the 1830s, was becoming – through the more famous work of Charles Lyell – more generally accepted. Gould's telling of this story[65] is quite interesting with regard in particular to the difference he teases out between what he describes as 'time's arrow' – the linear, progressive, historical time of events, and 'time's cycle' – the enduring, permanent time in which laws and order prevail. The notion of the cycle was certainly uppermost in the more theological notions of Creation put forward by Thomas Burnet, in his *Sacred Theory of the Earth* in the 1680s. It was Hutton, in the late 18th, and Lyell in the early 19th century, who foregrounded 'time's arrow' as the better description of the world, thus historicising it, whilst at the same time redrawing the notion of 'time's cycle' toward a permanence that rested on classical dynamics rather than God for its order and stability. Gould argues that Burnet's combination of arrow and cycle was in many ways more balanced than Hutton and Lyell's foregrounding focus on the arrow.

But that deep time could be as unfathomably vast as geologists now tell us, was – in Darwin's time – an insight still some way off. Darwin, at the time of the publication of the *Origin,* could only 'guesstimate' the time it may have taken for the formation of an area of southeast England (the Weald) to be somewhere around 300 million years.[66] The age of the earth was then such an incalculable uncertainty that Darwin made no attempt to suggest one. That it could be as old as four and half billion years was, at the time, unthinkable.

Darwin gives glowing praise for Lyell's 1830s *Principles of Geology*,[67] which he read in 1837 or early 1838,[68] and is keen to argue that Lyell's conception of geological succession contradicts the then traditional notion of the immutability of species, in support of his own theories of 'their slow and gradual modification, through descent and natural selection.'[69] He is confident, indeed, of his own views, because they are 'in strict accordance with the general principles inculcated by Sir C. Lyell.'[70] Lyell, indeed, was a figure Darwin was certain would be key for convincing the wider scientific audience of his own theory; Lyell was more than capable of using 'his considerable influence' to knock down a theory he disagreed with.[71] But what is perhaps most interesting about Lyell's views is that his 'concept of time was shaped to serve the ends of his concept of gradual, actualistic geological processes operating in a dynamically balanced, steady-state terrestrial mechanism.'[72] A world, in short, in accordance with the principles of classical mechanics: in which balance, equilibrium, and rest are the 'natural' state; to which any agitation will tend to return.

Situated, then, in this cultural milieu of classical dynamics and an ordered, balanced universe – with the newly foregrounded historicism of 'time's arrow' placing the earth into a long and progressive story, resting on 'time's cycle' of permanent, enduring laws – Darwin's ideas concerning natural selection were actually quite disturbing and revolutionary: in a way not even Darwin seemed happy to admit. 'The indeterminacy implied by natural selection fit somewhat uncomfortably with the Newtonian clockwork universe so central to the Victorian world view, and, in the end, evolution proved to be profoundly subversive to Victorian beliefs in stability, natural order, and progress,' Hagen tells us, in his history of the concept of ecosystems. 'But this was not obvious even to Darwin, who, though tending toward a view of natural laws as statistical summaries of phenomena, never completely broke with the more traditional notion of deterministic laws of nature.'[73] Indeed, as we have seen, it was the Laplacian view of chance and of such 'indetermination' that Darwin took, for all that the potential for innovation and random chance lies at the heart of the mechanism of natural selection.

It might be said, then, that Darwin's internal inconsistency came down to a clash between two metaphilosophical categories. One guiding 'root metaphor' for Darwin's explorations and for his life's work, clearly, was that of *mechanism*, and the rules of reductionist science where everything follows the laws of cause and effect. But another side to Darwin, as evidenced in the literary additions concerning the 'entangled bank', and his focus upon the organism, was clearly what Pepper would categorise as '*organicist*' – concerned with wholes, organisms, and a stable, holistic world of living totalities. This latter 'root metaphor,' indeed, was arguably the source of Lyell's belief in the steady-state, and with the wider beliefs in stability and natural order – the permanence of 'time's cycle' – whereby the totality of the world was ultimately in balance, and harmony reigned throughout. The uniformitarian settlement, placing God the Creator as divine clockmaker, gives to the mechanical universe an intentional, teleological whole: the progress of history has a plan, a finalism – the perfection of nature.

This holistic, *organicist* view was something immediately taken up by those with a more sociological imagination than Darwin's, most famously by the polymath Herbert Spencer, in his influential paper *The Social Organism,*[74] a year later, in 1860. Spencer was one of the most powerful voices in 19th century academia, a proponent of the notion of evolution even before Darwin, and an immense influence upon the young Bergson – who then saw through him and aimed much of his critique at his flaws. Spencer was also a classical liberal political theorist. It is, indeed, from Spencer that the oft-quoted phrase 'survival of the fittest,' stems.[75] This was not some revision of Darwin's ideas, but a pithy phrase encapsulating the fact that one of Darwin's greatest 'borrowings' from the ideas of his time, quite apart from the mechanistic backdrop of classical dynamics and the newly historicised world of the geologists, was in fact the notions of competition and struggle in the economic and social theory of Scottish Enlightenment figure, Adam Smith.[76] As Gould describes it, 'Darwin transferred the paradoxical argument of Adam Smith's economics into biology (best organisation for the general polity arising as a side consequence of permitting individuals to struggle for themselves alone) in order to devise a mechanism – natural selection.'[77] It is clear from Darwin's own notebooks that he read Adam Smith, and not just the famous *Wealth of Nations,* but his *Essays on Philosophical Subjects* too,[78] and he was familiar with the arguments in both Malthus and Smith on human populations and around the price of wheat;[79] and, although Darwin does not mention Smith in *The Origin of Species*, he does so in his later work, *The Descent of Man*.[80] As Höffding pointed out in the centenary celebration book, *Darwin and Modern Science,* in 1909:

> In accentuating the struggle for life Darwin stands as a characteristically English thinker: he continues a train of ideas which Hobbes and Malthus had already begun. Moreover in his critical views as to the conception of species he had English forerunners; in the middle ages Occam and Duns Scotus, in the eighteenth century Berkeley and Hume. In his moral philosophy…he is an adherent of the school which is represented by Hutcheson, Hume and Adam Smith. Because he is no philosopher in the stricter sense of the term, it is of great interest to see that his attitude of mind is that of the great thinkers of his nation.[81]

For Höffding, Darwin 'as a moral philosopher [thus] belongs to the school that was founded by Shaftesbury, and was afterwards represented by Hutcheson, Hume, Adam Smith, Comte and Spencer,' and has 'given this tendency of thought a biological foundation.'[82] We might just as well say that he reimagined biology – and evolution – in the manner of this 'tendency of thought.'

Schweber, famously, tells us, 'It is his study of Dugald Stewart and particularly of Adam Smith which reinforced [Darwin's] focus on the *individual* as the central element and unit in his theory and led him to adopt the Scottish view of trying to understand the whole in terms of the individual parts and their interactions,'[83] – the classic reductionist approach. This *Journal of the History of Biology* paper, by Schweber, entitled, 'The Origin of the *Origin* Revisited,' is the one Gould quotes as the source of his own understanding of the relationship between Smith's ideas and Darwin's natural selection. Schweber lays out a story in which Darwin, heavily influenced by his reading of (Brewster's review of) Comte's *Cours de philosophie positive*, spends much of the late 1830s trying to find a '*quantitative, mathematical*'[84] formulation, that was '*deterministic*'[85] – a theory that would incorporate 'natural selection, with the Malthusian principle as the *force* behind the selective process.'[86] That principle, which Darwin noted having come across in September 1838, stated that 'Population tends to increase in a geometrical ratio.'[87] (Bergson would say, of course, that this was a spatialisation – into geometry – of a mobile, and thus durational continuity.) The Malthusian graphs were focussed upon human population. Darwin extrapolated them onto animal and vegetable populations. Natural selection, moreover, Schweber informs us, was an idea Darwin had originally gleaned from pamphlets by Sebright and Wilkingson on animal breeding: 'As perceived by Sebright, artificial selection acts analogously to "Nature's broom" by eliminating inferior variations.'[88] It was, moreover, from 'the writings of Adam Smith and the other Scottish Common Sense philosophers that Darwin initially got his emphasis on individuals as the units for his theory of natural selection,'[89] contrary to his earlier concentration – in line with Lyell – upon species as the units of selection,[90] and, as Gould tells us, contrary indeed to his final acceptance that species must be considered units of selection *as well as* individuals.[91]

From these 'origins' one might, in fact, then, understand that farmers' animal husbandry designed for breeding better stock, a need to create a quantitative and deterministic formulation of a theory to satisfy the scientific circles of his day – not least Lyell – and the rather paradoxical, reductionist Smithsonian economics heaping all macro events onto the behaviour of individuals, all came together in Darwin's mind to coalesce into his evolutionary theory for which natural selection was the only and sufficient and all-encompassing mechanism: the *agency*, the *efficacy* and the *scope*. Yet, even Adam Smith's 'free agents' seemed lost to the individualism of Darwin's organismic natural selection. At bottom, Darwin's mechanism of natural selection 'implied a commitment to a materialistic explanation which denied to living organisms an ontological status different from that of inanimate objects.'[92] It was cybernetics before cybernetics, reducing all life to clockwork automaton status on a Malthusian graph, with the dead hand of classical mechanics as the husbandman making the 'natural' selections.

Gould, let us recall, characterised Darwin's insistence on individuals as the units of selection for evolution as being the *agency* of his evolutionary theory; that natural selection was the only force in building evolutionary novelties constituted the *efficacy* of his theory; and, by extrapolation, the *scope* was that natural selection at the individual level, as a mechanism, can explain 'the full panoply of life's changes in form and diversity.'[93] One might equally characterise Adam Smith's economic theories in this way. That individuals – who, for Smith, are free agents – are the units of selection of social activity, constitutes the *agency* of his economic theory; that competition and struggle among individuals are the only forces producing social phenomena is the *efficacy*; and the *scope* of the theory contends that the entirety of human social life, and its stability, functions *naturally*, without human design or direction, solely by the combined effect of individual competition and struggle. That society should be allowed – without interference – to be determined by such individual competition and struggle is the moral conclusion. The chance element, which Darwin relegated to mechanistic laws only Laplace's demon could see, is that, for Smith, individuals are accorded free will. Nonetheless, for Smith just as for Darwin, 'there is an ensuing order (as if each individual were "led by an invisible hand").'[94] For Schweber it is thus clear that:

> the philosophy of individualism which Darwin reflects (in particular, the analogy of free agents and chance variations) is more characteristic of Smith's writings than of Malthus's. Individualism in Malthus is primarily expressed in man's exercise of moral restraint (in order to avert catastrophe) and does not animate his system. My emphasis on Smith's influence on Darwin also accounts for the somewhat guarded optimistic naturalism that Darwin expresses. It reflects Smith's view. The Malthusian mood is more sombre and pessimistic. The *Essay on Population* was after all originally written to disprove the perfectibility of man.[95]

Economists to this day often claim that such market-oriented economic philosophy as Adam Smith's reflects the 'natural' state of things, and should be allowed its head: regulation by government is the enemy of this ‘natural’ market and distorts it. Such economists often quote Spencer’s epithet, ‘survival of the fittest.’ Clearly, however, it is a circular argument, for the very notions they claim are ‘natural’ were apportioned to nature after, and in reference to, the ideas of Adam Smith: natural selection, as a theory of evolutionary change, in fact uses the arguments of the father of modern capitalist economics to describe nature. Hagen tells us, critiquing Spencer, that ‘A glaring weakness in Spencer’s argument is the rather naïve anthropomorphism of his organic analogy,’[96] but one might, in fact, suggest that the anthropomorphism involved was the characterisation of the processes of evolution in the terms of economic theory by Darwin himself.

The rugged, individualistic, now more famously American than Scottish creed of capitalist economics begun by Adam Smith was strong in Spencer, who, championing Darwin’s use of the notion of individualism, competition and struggle in describing evolution, declared that, ‘the different parts of a social organism, like the different parts of an individual organism, compete for nutriment.’[97] Many modern day market fundamentalists and libertarians, indeed, regard Spencer, rather than Smith, as their original precursor.[98] The harmony of the universal totality, for Spencer, was best and ultimately achieved by allowing the free competition visible (to him) in Darwin’s theory of evolution. More, perhaps, than Pepper’s *organicism,* this was akin to the finalism Bergson so strongly critiqued in *Creative Evolution,* when he described Spencer’s as a ‘false evolutionism…which consists of cutting up present reality, already evolved,’ – the vigorous capitalism of the 19th century – ‘into little bits no less evolved, and then recomposing it with these fragments, thus positing in advance everything that is to be explained.’[99] The magic, ‘invisible hand’ from which ‘order’ is supposed to arise, from the competition and struggle of so many self-interested individuals, remains unexplained, undescribed, and ill-thought out: indeed, given the inequality it drives, one might suggest that the ‘invisible hand’ is not even supported by the facts. Both for economics, and for evolutionary theory, it smacks of an apology for the right of might: that the most selfish and vicious individuals rise to the top creates an order in society and in nature that should be seen as ‘natural’ – determined by physical laws.

For Bergson, by contrast – and for complexity ecologists, as we shall see in the next chapter – the competition and struggle of individuals is a secondary, modifying mechanism in evolution: units of selection – as we have seen from Gould, other than individuals, including genes and species, with their own mechanisms – are also key to evolution, and overarching structural forces as various as cladal trends, geologic and asteroidal mass extinctions, fitness, niche, accidental and co-adaptations, are all involved in driving a far more complex evolution than Darwin's simplistic, individualistic formula. The guiding structural forces of government regulation, one might say then, of central economic planning, even, with the competition and struggle of individuals kept in a bounded market, might be a better reflection of the 'natural' world, if a 'natural' economy is one that we wish to seek.

Spencer's ideas, however, took hold in the scientific as well as the sociological and political community. By the beginning of the 20th century, Lawrence Henderson, one of the forerunners of systems theory, could assert, in 1913, that 'the whole evolutionary process, both cosmic and organic, is one, and the biologist may now rightly regard the universe as biocentric.'[100]

The *positivity* of the notion of ecosystems, then, traces the economic ideas of the Scottish Enlightenment through the geology of Hutton and Lyell, into the evolutionary biology of Darwin and the sociobiology of Spencer. Right from the outset, a strange composite lies already at the heart of the ecosystems concept: a *mechanist*, reductionist classical dynamics; a more romantic, *organicist* notion of a holistic, stable natural order; and, somewhat paradoxically, an equally reductionist/individualist market economics as its guiding moral philosophy. As Bergson would put it, such a composite rendered the concept of ecosystems a false problem, from the outset. As Hagen underlines, too, the indeterminacy of the notion of natural selection, running through it, contradicted both the mechanistic and holistic order, introducing novelty where all was supposed already to be laid out and planned, albeit visible only to the demon of Laplace.

Epistemologisation

The next genealogical threshold would not come until the early 20th century, with the *epistemologisation* of the ecosystems concept, and the rapid *positivity* and *epistemologisation* of systems theory. This story takes in the establishment of ecology as a discipline, its sociobiological holism, and the first formulation of the concept of emergence, and how a system might display properties not reducible to its component parts. It embraces the onset of systems thinking first in biology, and then extrapolated into other fields of knowledge, and the influx of pure mathematicians into the applied sciences.

In 1913 Arthur Tansley was elected as the first President of the British Ecological Society,[101] and the *Journal of Ecology* was established to carve out the discipline. Thus the discursive formation of the ecosystem concept set itself up with a group of statements against which others are to be judged true or false, and began to exercise 'a dominant function (as a model, a critique, or a verification) over knowledge'[102] in the field of environmental biology. It was Tansley who first coined the term 'ecosystem' in his paper criticising Clements' holism in 1935.[103] Arthur Tansley was the first ecologist[104] to develop and refine the definition of the word 'ecosystem,' but – notably – it was principally in answer to what he saw as the misuse of a related concept, 'the Complex Organism,' by fellow ecologist John Phillips. Tansley's criticism was of articles published by Phillips in the *Journal of Ecology* in 1934 and 1935, the last of which, as Tansley puts it, 'is mainly concerned with the relation of this…concept to the theory of 'holism' as expounded by General Smuts and others, and is really a confession of the holistic faith.'[105] The internal contradictions between *mechanism* and *organicism* in this composite concept, in short, remained strong.

Smuts' 1926 book *Holism and Evolution*,[106] (the basic holistic premise of which was adopted by Clements[107]) made no pretence to scientific validity: he suggested that, due to the extraordinary length of geological time, no laboratory-based experiments could prove or disprove his thesis.[108] Nonetheless, Smuts believed, the principle of wholes gathered together in ever greater wholes, up to and including the ultimate totality, was sufficient principle for the understanding of life and of society: life, the universe and everything, on the model of the Russian doll. This thesis, written in opposition between periods as Prime Minister of South Africa, was no doubt suited to a politician (and General) of the British Empire and vigorous proponent of the League of Nations. It was also, unfortunately, well suited to an equally vigorous proponent, as he was, of segregation between what he regarded as the evolutionarily advanced white race, and the black races of the continent over much of which his Empire ruled. These segregation rules formed the foundation of the later apartheid.

Holism, however, was not the only theory being put forward at the time. Vitalism, put forward by scholars such as Driesch, Willis and Stahl, was a strong voice in the latter part of the 19th and early decades of the 20th centuries, to many a welcome counterweight to the dead hand of mechanism. There were also the emergentists (notably Lloyd Morgan's work on animal psychology[109]), who arose and began to advance a middle path between the classical mechanists and the vitalists, that acknowledged the need for an understanding of mechanics and a general adherence to the laws of physics, whilst at the same time denying that all phenomena could be reduced to physics, or simplified to a mechanical explanation. For Morgan, in his discipline-defining *An Introduction to Comparative Psychology* in 1894, according to the then current principles of evolution, 'the presence of any faculty in higher types involves the germ of this faculty in lower types.'[110] This relies on an assumption that, 'the evolution of higher faculties out of lower faculties is impossible,' a highly mechanistic, and, as Bergson would argue, finalist assumption, requiring the outcome of evolution to already be determined at its inception. Morgan continues, 'Those evolutionists who accept this assumption as valid are logically bound to believe either (1) that all forms of animal life from the amoeba upwards have all the faculties of man, only reduced in degree and range, and to interpret all animal psychology on a method of reduction (though not necessarily uniform reduction), or (2) that in the higher forms of life the introduction of the higher faculties has been effected by some means other than that of natural evolution'[111] (i.e. divine providence). As we have seen, Bergson's answer to this problem is profoundly different, founded, as it is, on his wider metaphysical reconstruction beyond the Cartesian divide, and not relying, as Morgan was, on a divine solution.

Emergentism, nonetheless, was to mark a pivotal advance towards systems thinking. As Morgan stated in his 1923 book, *Emergent Evolution,* 'Evolution, in the broad sense of the word, is the name we give to the comprehensive plan of sequence in all natural events. But the orderly sequence, historically viewed, appears to present, from time to time, something genuinely new. Under what I here call emergent evolution stress is laid on this incoming of the new.'[112] This first exploration of the concept of emergence was extremely challenging to the analytic tradition of the day, but – as we shall see in Chapter 5 – is now something of a cornerstone of contemporary complex systems thinking.

Morgan acknowledges his debt to Bergson – 'I fully subscribe to M. Bergson's doctrine of mergency and interpenetration as applicable to mental process as such,'[113] whilst also accenting where his own conclusions differ from Bergson's.[114] But Morgan's wider project insisted on the inevitability of a spiritual dimension, which, although appreciated in the Gifford Lectures in Edinburgh in the 1920s, was anathema to the strictly secular discipline of psychology established in America, keen to remain on the mechanistic side of the Cartesian divide. This more functional psychology (although open to exploring the social usefulness of religious and ethical themes) was antagonistic to theism of any form, preferring its own strictly naturalistic ontology. Hence, potential American allies – such as, James, Dewey, J.R. Angell, and H. Carr – were lost to Morgan, and, like Bergson, his work and ideas faded from view and are now only available in archive form in libraries, more as a curiosity than as a recognised contribution to the field.

Nonetheless, Morgan's ideas were current in the intellectual milieu of the period, and the challenge of his emergentism to the reductionist view opened up the conceptual space within which the new notion of what a system might be could develop. Systems, in a living world in which emergence was taking place, and considered as a whole, could be argued to have properties and perhaps even laws, that were different from, and could not be reduced to, the properties and laws of their components. The whole, in other words, could display properties not reducible to its component parts. This was a much-refined understanding of wholes in comparison to Smuts' holism, which was by contrast deterministic. It allows, moreover, the kind of layering, or hierarchical ordering of systems within and alongside other systems, wherein each system can have its own rules and behaviours, as well as impacts upon one another.

This new concept of the whole, and of emergence, moreover, was the explicit assertion of Ludwig van Bertalanffy. In the late 1920s, Austrian biologist Bertalanffy[115] published his *Modern Theories of Development, an Introduction to Theoretical Biology,* in which he expressly promotes the idea of 'organicism' (not to be confused with Pepper's metaphilosophical category, but nonetheless closely related). Organicism, for Bertalanffy, was a theoretical position that suggested that systems of many kinds – not just living organisms – could, and should be treated as organisms with multiple hierarchical levels, with properties in total, at each level, that were irreducible to their component parts.

Thus, the notion of systems that display properties not reducible to their component parts, reached *positivity* and *epistemologisation* in one go, as it were, with the ecologists' notion of ecosystem as their foundation. Bertalanffy's notion of organicism no doubt echoed De Vries' earlier acknowledgement of species selection, as well as Morgan's concept of emergence, and was later to be taken up by Gould and Eldridge in their formulation of a decoupled hierarchy of units of selection at the different levels of gene, organism, and species. Bertalanffy's unique contribution was to expressly abstract a 'principle' from these evolutionary ideas: the notion that this concept of system, with laws and multiple levels, could be applied in all manner of different contexts, not just in biology. Yet genealogically Bertalanffy's contribution was clearly in keeping with the discourse of his day: the reductionism of classical mechanics had been challenged not just by the politically motivated (Smuts) and the religiously inspired (Morgan), but by one of the most famous philosophers of the time, Henri Bergson, and – perhaps most crucially for Bertalanffy – by physicists themselves.

Interestingly, one branch of physics – thermodynamics – and Carnot's first scientific use of the word 'system,' in his description of a heat engine a hundred years before, become crucial here. In short, the subjects of biology – living organisms – seem not to adhere to the laws of thermodynamics. The laws of thermodynamics incorporate the notion of entropy – the inevitable loss of energy in any heat exchange, and the tendency in the universe toward a final loss of all energy, an equilibrium of rest when all things come to a halt. Counter to this entropy of thermodynamic equilibrium, in what Bertalanffy termed 'flow equilibrium,' living systems, by contrast, maintain themselves in a high state of order. As Bergson had stressed a quarter of a century previously, in *Creative Evolution,* 'No doubt, every living cell expends energy without ceasing, in order to maintain its equilibrium.'[116] Bertalanffy coined a new German word, *Fliessgleichgewicht*, for this flow – later translated into English as 'steady state'. Similar in many ways to Lyell's geological steady state, Bertalanffy's biological steady state was the apparent stasis achieved by living cells that maintain a high state of order in the face of entropy.

But Bertalanffy's was not the only voice, in the early decades of the 20th century, *epistemologising* the notion of systems. Henderson, too, whose Spencerist biology was by now making a gradual move toward sociology, was characterised in Lilienfeld's study of the rise of systems theory as putting forward an 'organicist equilibrium,' of primary importance in the history of systems. For Henderson, 'The organism possesses a self-regulating mechanism whose goal is the maintenance of equilibrium (health); a condition of disequilibrium defines illness.' For Lilienfeld, Henderson thus explicitly likens simple mechanical/dynamical systems that one can represent in diagrams, with biological, and even social systems.[117] Many characteristics of later systems thinkers are foreshadowed in Henderson's work, in Lilienfeld's view, and indeed Henderson was one of the first thinkers in this field to make such use of the term *system:* 'his scientism, his passion for quantification, and his enthusiastic and somewhat simplistic belief that systems models can adequately encompass the totality of a society',[118] however, for Lilienfeld, meant that he was setting systems theory off down a dangerously dehumanising road.

Henderson's friend and colleague at Harvard, Walter B. Cannon, in his 1932 *Wisdom of the Body,* meanwhile, developed the idea of *homeostasis:* a condition that may vary, but which is relatively constant. Cannon's work focuses largely around such organic mechanisms as blood-sugar levels, adequate supplies of oxygen, and body temperature. But, as Lilienfeld points out, Cannon then goes on to elaborate a social analogy, arguing – interestingly – against individualism and for central controlling mechanisms: 'He draws a direct analogy between the "fluid matrix" of animal organisms and the transportation system of a state or nation – railroads, canals, rivers, roads – with the boats, trucks and trains serving as common carriers, like the blood and the lymph; wholesalers and retailers represent the less mobile portions of the system. Thus, products of farm, factory, and the like are carried back and forth.'[119] The 1930s, we must recall, was a time when the individualism of market economics was being challenged by the central planning of communism: both these economic and political theories fought to co-opt biology and ecology – and systems thinking – for their support.

The *epistemologisation* of the notion of ecosystems and systems thinking during this period was characterised, however, not solely by the role of biology and ecology. The mechanistic scientism of the 19th century had overtaken philosophy, in Bertrand Russell's logicism, by this time, and the worlds of physics, chemistry, biology and other applied sciences were newly host, in the 1930s, to an influx of pure mathematicians, who had lost their way.

This was the era in which Gödel (in 1931) formulated and proved his incompleteness theorems, and in which the greatest concentration of gifted mathematicians, under David Hilbert's Göttingen School, were purged of Jewish scholars in 1933 by the Nazis. Hilbert's programme, of course, to find a complete and consistent set of axioms for all mathematics, was by then already broken by Gödel's incompleteness theorems. Gödel had proven the inherent limitations of logic – 'Any effectively generated theory capable of expressing elementary arithmetic cannot be both consistent and complete.'[120] Hilbert's programme was therefore a dead end. Bertrand Russell's attempt to found philosophy in logic was thereby, arguably, equalled doomed, for all the popularity of his *Principia Mathematica,* penned with Whitehead.

It was Hilbert's assistant, John von Neumann, who, disappointed that pure mathematics could no longer bear the fruit Hilbert had once promised, turned his attention, instead, to physics, left Germany for the United States, and, by the end of the 1930s, had become an expert on the science of explosions. As von Neumann himself characterised his 'second phase,' as a US citizen and military advisor from 1937 to 1947: 'My personal opinion, which is shared by many others, is, that Gödel has shown that Hilbert's program is essentially hopeless…I think that [this story] constitutes the best caution against taking the immovable rigor of mathematics too much for granted. This happened in our own lifetime, and I know myself how humiliatingly easy my own views regarding the absolute mathematical truth changed during this episode, and how they changed three times in succession!'[121]

At the very time, in other words, that mathematicians themselves were realising that mathematics was limited, applied scientists, like Henderson, were trying to make biology fit within the reductionist, mechanistic model of classical dynamics. The rise of systems theory, therefore – in which emergent properties of wholes could not be predicted from component parts – both contradicted the prevailing penchant for logic, at the same time as reflecting the discovery of the greatest of all logicians – Gödel – that logic had its limitations. It was, as Bertalanffy was beginning to point out, a fundamental difference, between the notion of closed (predictable and calculable) systems, and 'open' systems, consisting in multiple overlapping influences and emerging and changing conditions: between, in other terms used by Bergson, the fixed and the mobile.

It is Bertalanffy's 1950 paper in the distinguished journal, *Science*, titled 'Theory of Open Systems in Physics and Biology', which is widely credited as the seminal work in modern systems theory – its *epistemologisation*. Along with establishing the notion of 'open' systems with emergent properties in both living and non-living conditions, Bertalanffy's paper suggests that any 'steady state' requires that systems be 'open,' rather than 'closed,' if the contradictions between classical mechanics and thermodynamics are to be avoided. The developments in 'emergentism,' and in Bertalanffy's seminal 1928 book,[122] can be seen, at least in part, as a precursor. The dominant, analytic (logical positivist) and reductionist approach to science in the 19th and early 20th centuries – which had been the target of Bergson's critique – and the growing awareness amongst mathematicians, biologists, psychologists – and, of course, social scientists – of the limitations of such an approach, was slowly but surely opening up a space in which a new movement could seek to provide an alternative.

The word 'system,' let us remember, to an analytic/logician philosopher or scientist, meant simply the object or objects of interest. This usage, however, did not attribute any properties to a system. It was no more than a convenient label for the collection of interacting objects under investigation. With Bertalanffy, the more substantial conception of what a system might be, albeit heralded by Morgan and others, truly began to arise: *epistemologisation* was being achieved.

With *epistemologisation*, then, ecology had been established as a discipline, with its own society and journal, and biologists had begun to describe environments as ecosystems, organisms as living systems; the notion of 'systems' itself had become a concept that could be applied to inorganic, as well as organic, objects of interest. Most importantly, the notion of emergence had been added to the mix, allowing for new properties to be discovered and described, in systems that could not be reduced to their components, and could be regarded as 'open' systems. Thus, the novelty and innovation of evolution – implied by Darwin's natural selection as much as by Bergson's *élan vital* – was beginning to find conceptual space, at a systemic level, at least.

But the tension between the *mechanistic* and the *organicist*, in Pepper's terms, remained, with Henderson's self-regulating mechanisms and Cannon's 'fluid matrix' societies, Tansley's patient botanical taxonomy and Clements' holistic integrity all vying for space. Even the divine clockmaker had put in an appearance, as the possible source of novelty amongst the 'higher species', in the development of the notion of emergence. Still, the truly radical implications for both mechanism and organicism presented by the unfolding of novelty of Bergson's driving force, of which the innovation of natural selection was but a modifier, was only just beginning to make itself felt, in Bertalanffy's 'open' systems notion.

Scientificity

The *scientificity* phase occurred during and after the Second World War, through which the systems science of cybernetics was developed, and ecology became mathematicised. The *mechanistic* root metaphor, in Pepper's terms – perhaps understandably, given the nature of *scientificity* – seemed largely to the fore during this period, yet the romantic, *organicist* metaphor of wholes in equilibrium remained the underlying logic of each mechanism: the composite of the two, indeed, lies at the heart of cybernetics. Market economics, at the heart of Darwin's original formulation, again appears in the story.

When a discursive formation achieves *scientificity,* it does so primarily by obeying 'a number of formal criteria, when its statements comply…with certain laws for the construction of propositions.'[123] In essence, then, *scientificity* is about the constitution of science as science, and in a historical period conditioned by modern warfare, science is scientific to the extent that it supports the agendas of those leading the war effort. Arguably, science as science, in this sense, had already in the US for several decades been conditioned by the funding opportunities available from the Rockefeller and Carnegie Institutes, both interested primarily in the concerns of their founders, which were strictly commercial.[124] In the lead up to the Second World War this was to change radically, as the full weight of government control and financial muscle was – for the first time – directed into scientific research. Those who could contribute scientific expertise to the war effort received the support of those leading that effort. In the summer of 1940, this was made concrete in the deal between Churchill and Roosevelt to pool and jointly further their secret research. The impetus for this was the ongoing work into range-finding and direction, using ultra-high frequency radio or microwaves, to which British researchers John Randall and Harry Boot at Birmingham University had contributed the easily usable source of such high frequency microwaves: a resonant cavity magnetron. US researchers called this process RAdio Detection And Ranging – and the name RADAR stuck, but the secret research laboratories established by the joint effort of these allies used cover names, such as the then slightly less obvious 'Radiation Laboratory'. It was this laboratory – and its work towards the war effort – that gave birth to cybernetics.

Cybernetics was a concept developed largely by Norbert Wiener. Awarded a PhD at Harvard in 1912, at the tender age of 17, for a thesis on mathematical logic, Wiener was a student of Bertrand Russell's at Cambridge University in 1914, and, after the war, joined the Massachusetts Institute of Technology (MIT), where he remained for the rest of his career.[125] John von Neumann, Auturo Rosenblueth, Julian Bigelow, Warren McCulloch, and Walter Pitts were all important names in the development of cybernetics, as was the Radiation Laboratory (known as the RAD Lab) at MIT, where several of them worked, and the series of interdisciplinary conferences sponsored by the Josiah Macy Foundation after World War II. Many others lent their work and their name to the development of cybernetics, including Ross Ashby, Claude Shannon, and others. The Macy conferences were designed to present the new field of cybernetics to the broader scientific community.

As with Bertalanffy's steady state flow equilibrium (and his later 'open' system concept) the starting point for cybernetics grew out of the apparent contradiction between the second law of thermodynamics and the evidence of evolution: living systems, contrary to the notion of entropy, maintain themselves in a high state of order. For Bertalanffy, this meant systems needed to be considered as open. For Wiener, the mathematical logician, however, they could remain closed, and fit within the logical process modelling of both classical and thermodynamics: Wiener's systems – both mechanical and biological – would return to equilibrium after being disturbed, by regulating themselves through the mechanisms of feedback. Biological systems, then, à la Henderson and Cannon, could be considered automatons.

Cybernetics, then, was the study of such closed systems: of the mechanisms of self-regulation, feedback, oscillation, and time lag. Wiener's work came about from a project at the RAD Lab, in 1940–42, seeking a solution to the 'wartime problem of designing an automatic control system for anti-aircraft guns.'[126] The control system needed to aim the gun not at the aircraft itself, but toward a possible future position of the target. Relying on the skill of human gunners, as enemy aircraft and rockets got faster and faster, was proving both ineffective and wasteful of ammunition. The resulting Signal Corps Radio #584 (SCR–584 for short) was a microwave radar capable of tracking a moving plane. Coupled to Bell Labs' 'M9 Director' analogue computer that could take the electrical data from the radar and convert it into mechanical targeting of the gun emplacements, the system was demonstrated in April 1942 and immediately put into production. 'Information, in this case the difference between the present position of the gun and the future position of the target, was used to modulate the movement of the gun. Properly constructed this feedback mechanism would produce a series of dampened oscillations, swinging the gun in a smooth arc until it arrived at the proper firing position.'[127] Wiener and Bigelow worked on the problem together, and, with Rosenbleuth, developed the ideas that had gone into its creation into a paper which quickly took on the air of being a manifesto for a new field of study: 'Behavior, Purpose and Teleology,' in the journal, *Philosophy of Science*.[128] Thus, cybernetics was born.

In the world of ecology, meanwhile, Hutchinson saw how this notion of feedback could be used to model the behaviour of populations. Hutchinson[129] and his protégés (especially Lindeman[130]) adopted the tenets of cybernetics and proceeded to mathematicise ecology. As the Modern Synthesis in evolution was being formed by the likes of Julian Huxley, Hutchinson proposed that ecology could usefully be divided into two broad approaches: 'One, the *biogeochemical* mode, involved the interdisciplinary study of the movements of materials and energy through the biosphere. The second mode of ecological research was *biodemographic*. This approach was purely biological, studying numerical variations in the sizes of populations.'[131] Hutchinson proposed that the two approaches could be unified into the concept of negative feedback. A whole symbolic, quasi algebraic language was developed by Hutchinson and Lindeman, to represent and calculate the behaviour of species, resting on the cybernetic principles of self-regulation and feedback tending back toward equilibrium and rest.

Thus, the notion of ecosystem was recast in axiomatic, logical, and mechanical terms, such that it took on *scientificity.* In this way the new mechanistic science of ecology became imbued with the mathematics and influence of John von Neumann – a key player at the Macy conferences and influence upon both Hutchinson and Lindemann; with Norbert Wiener's cybernetics; and with the corresponding developments of the new field – born of the war effort – of Operations Research; and with its close relative – developed principally at Bell Labs – Information Theory. The mechanistic metaphor of the system remained, therefore, as strong as in Darwin's day, albeit that – as von Neumann himself knew all too well – the dream that mathematics could answer all questions had already been lost. But the point of feedback and self-regulation is to regain equilibrium, to return to a restful whole, and the whole process renders the system *organicist. Mechanism* and *organicism* again – still – in composite.

Meanwhile, in the interwar years, whilst the epistemologisation of systems was underway, the association of the openly *organicist*, holistic approach to ecosystems with the libertarian economics of Herbert Spencer and the supremacist views of Jan Smuts, had also continued to evolve. Fierce battles raged concerning the best economic systems: between, on the one hand, the Spencerian promoters of the virtues of the market; and, on the other hand, the 'socialist calculation' that total central planning was the only way to run a rational economy. This was the classic standoff between capitalist and communist systems, between the Anglo-American and Soviet models, and the trade union and socialist movements in Europe and America sought rational central planning where the market fundamentalists insisted that only free competition would enable the equilibrium of the social organism.

Central planning did, indeed, in the end – in the form of the military industrial complex, pulled together and run, in large measure, by Vannavar Bush and Warren Weaver[132] – win the Second World War, against an equally centrally run National Socialist (Nazi) machine whose principal failing was arguably the irrationalism of its leader – and all the horrific consequences of its eugenicism. In this military-industrial complex, moreover, Bush and Weaver constructed 'the most targeted and micromanaged scientific research effort in the history of the United States.'[133] One of its most celebrated consultants, with the highest security clearance – the expert in explosives John von Neumann – moved from the RAD Lab to the Manhattan project to work with Oppenheimer on the atom bomb. By the end of the war, using Turing's insights, von Neumann had penned the world's first comprehensive description of the design of an electronic stored-program computer, *First Draft of the Report on the EDVAC* which 'rapidly became the design bible of the nascent computer community.'[134]

But in the post-war years, the McCarthyite fixation on opposing all aspects of the Soviet central planning approach included ensuring that the Spencerian market approach – and everything associated with it – prevailed, not just in America, but anywhere American influence could be brought to bear. The Cowles Commission, at University of Chicago, and then Foundation at Yale, was the academic home of such market economics, and was led from 1948–1955, by the influential economist Koopmans, a protégé (since Koopmans' paper of 1942 caught his eye) of John von Neumann's. The Cowles men preached a new gospel: they were 'mathematical economists [who] could aspire to be the antiseptic "software engineers" of the brave new world of economic planning,'[135] and one of their most famous ideas was general equilibrium theory. For critical economist Mirowski, in fact, 'The rise of theories of science planning, organisation, and policy [through the war] and the rise to dominance of neoclassical economic theory within the American context are all different facets of the same complex phenomenon.'[136] The argument around Smithsonian/Spencerian individualism, in other words, continued to rage. In the 1930s, as Mirowski points out, it was in the specific context of the socialist calculation controversy that classical liberal economist Friedrich Hayek 'found himself appealing to this nebulous "thing" that the market processed but the central planner lacked:' information. Like Smith's 'invisible hand' the information that free agents in the market had access to was something vast and unknowable, and quite separate from the allocation of resources and finance of traditional economics. The information that a central planning authority would need, Hayek argued, to run an economy rationally from the centre, would have to be so exhaustive as to render anything that could reasonably be gathered virtually non-existent. 'The need' in other words, Mirowski concludes, 'to refute "market socialists"... thus led directly to the initial landmark revision of the image of market functioning away from static allocation and toward information processing.'[137]

Information Theory – spawn of the mathematical optimisation of operations management in Bush and Weaver's military-industrial complex that had shifted so much weaponry, ammunition, and manpower around the world, and Shannon's fire-control systems research at Bell Labs – was by the 1950s set to support and manage the very opposite of such central planning: the free market economy. According to the Cowlesmen, moreover, the point of this information processing in the economy was to achieve equilibrium: the restful perfection of classical dynamics.

In ecology, too, the logic of the military-industrial complex, established by Bush and Weaver, continued to exert its influence through the post-war years. Ecosystems research was undertaken in the 1950s largely – by the Odum brothers – on irradiated atolls in the Pacific, following nuclear tests, and a transformation of ecological metaphors, 'a gradual shift from organic to machine images,'[138] took place as the 1950s unfolded. Coral reefs became 'self-regulating systems' in this new language of ecology, represented by Hutchinson and Lindeman's algebraic formulae, to the point where Howard Odum could declare, in 1959, that, 'The relationships between producer plants and consumer animals, between predator and prey, not to mention the numbers and kinds of organisms in a given environment, are all limited and controlled by the same basic laws which govern non-living systems, such as electric motors and automobiles.'[139] Ross Ashby's *Introduction to Cybernetics* was a textbook in Patten's marine ecology course, in the 1960s.[140]

In 1966, crowning the rise of cybernetics just as its second wave was about to supplant it, *The Theory of Self-Reproducing Automata* posthumously published von Neumann's lecture notes on the topic. As Mirowski quotes from it, such a general theory of automata:

> would apply indifferently and without prejudice to molecules, brains, computers, and organisations. Amidst this generality, the architecture of computers would stand as paradigmatic and dominate the inquiry, if only because, "of all automata of high complexity, computing machines are the ones we have the best chance of understanding. In the case of computing machines the complications can be very high, and yet they pertain to an object which is primarily mathematical and which we understand better than we understand most natural objects" (von Neumann, 1966:32)[141]

The *scientificity* of the systems concept, in other words, looked to the computer for its ultimate metaphor: a closed (organicist) system full of cybernetic loops, modelled on mathematical (mechanistic) processes. The composite remained, and still, the inherent problem of novelty implied both by natural selection and the *élan vital*, remained unaccounted for. But it was soon to make its mark, and as *formalisation* was reached for, this composite was set to fall apart.

Scientific revolution

Despite the hopes of the early cyberneticians, this mechanistic systems theory of automatons did not achieve *formalisation*. A 'second wave' of cybernetics realised that the observer of the system *had* to be taken into account. With the work of Margaret Mead, Gordon Pask and Stafford Beer, among others, cybernetic systems began to 'open' up. Bertalanffy's (1950) *Theory of Open Systems in Physics and Biology*[142] and (1968) *General Systems Theory*[143] and Laszlo's (1972) *Introduction to Systems Philosophy*[144] showed the way forward beyond the closed systems of the first order cybernetics and paved the way for newer understandings of complexity, whose first shoots were already visible in the early 1960s: for example, with Simon's work on hierarchical complexity architecture.[145]

The key problem – not just with Darwin, but, perhaps, epitomised in Darwin's 'entangled bank' – is that the ordered world of equilibrium described in classical dynamics is fine and apt when applied to the extraordinary machines the era was witnessing – from the first steam train to the vast military-industrial machine of the Allied economies; but, as a metaphor for the living world it was not only limiting, but inaccurate. It was a misleading metaphor, and had led to some very distasteful outcomes – not least the ideas and political actions of Jan Smuts.

Contrary to the beliefs of 19th and 20th century evolutionary theorists, static, equilibrium-based, coherent systems, were – as the latter part of the 20th century unfolded – exposed as dead, *mechanistic,* machinic systems, that *do not occur* in the natural world. The algebraic, axiomatic diagrams of ecologists such as Henderson, Hutchinson, Lindemann, and the Odum brothers were, as the latter part of the 20th century unfolded, increasingly exposed as simply not supported by the data which was being painstakingly gathered in the field.

Dynamic, constantly changing, nonequilibrium, open systems that – in a word – *evolve*, by contrast, are what *do* occur in the natural world. The attempt by Darwin to create a mechanistic, quantitative formulation of evolution theory in order to satisfy the scientific community of his day, mingled with the rather more ancient organic holism of his more romantic imagination, had created more problems than it had solved. The composite of *mechanism* and *organicism,* in other words, was challenged, pulled apart, and shown for what it really refers to. It is, ironically, only *mechanistic* systems – manufactured by man – that achieve the equilibrium and stability of the 'wholes' of the *organicist* metaphor. Living systems, by contrast, turn out to exist only at far-from-equilibrium states, at the edge of chaos.

Similarly, the individualism of Adam Smith and Herbert Spencer – of Hayek and the Western world's opposition to the Communist bloc – proved, in the latter part of the 20th century, to be a political theory not supported by ecological or evolutionary reality. 'Individuals are alive,' for sure, 'but an individual cannot sustain life.'[146] Life, according to contemporary ecology, is sustained only by a group of organisms of many species, and the individualism of Darwin's natural selection is insufficient in *agency, efficacy,* and *scope* as an explanation of evolution. Individuals are sustained by living in a system composed of many individuals of different species and their environment. These insights and developments will be the concern of the next chapter.

With the onset of the 1960s, then, and the explosion of poststructuralist ideas, and the beginning of the rediscovery of Bergson, the *mechanistic* worldview was (again) being challenged and questioned. The *organicist* worldview fed into the countercultural environmental movement, which delighted in the holistic models of ecology just when ecologists themselves were, for the first time, beginning to question whether the natural world did indeed exhibit the kind of holistic equilibrium so many ecologists of the early 20th century had believed. This is another story for which there is not room in this volume. Suffice it to say that it seems the 1960s environmentalist counterculture, as Turner[147] points out, developed into the entrepreneurial cyberculture of the 1970s and 1980s, that embraced libertarian economics as well as the new computers, and the selfish individualism of Ayn Rand, and have helped to create the modern borderless world, in which the liberal self, armed with a smartphone, can, in pursuing his/her own interests, somehow rest assured that the wider interests of humanity as a whole are thereby served, and that this is the 'natural' way forward. (On the contrary, unfortunately, it is probably why we may be witnessing, as a result, the greatest mass extinction[148] since that of Chicxulub.[149])

As Bergson – one of Pepper's *contextualists* – had pointed out, however, over a century ago: everything is, in fact, a great deal more contingent than this. Collectivities, indeed, and the emergent novelties that arise from such collaborations, turn out to be how living systems really work: a challenge, not just to Darwin's individualist natural selection – as the primary, and only mechanism of evolution, capable of producing all the panoply of life we witness in the world – but also to the economic notions of competition and struggle from which Darwin derived the idea in the first place.

Notes

1. Carnot, N. L. S. (1897) *Reflections on the Motive Power of Heat* ed R.H. Thurston, New York: John Wiley http://www3.nd.edu/~powers/ame.20231/carnot1897.pdf Sadi Carnot published his essay at the age of 23 in 1824, and then went into politics and rose to the Presidency of France. In 1824 William Thomson (Lord Kelvin) was born. Clapeyron's work in 1834 and 1843 developed these ideas, but it was not until Kelvin was himself in his early twenties that Carnot's work was fully recognised and brought to Kelvin's attention in arguments by Joule, in 1847, at Oxford. In short, although the first use of the word 'system' in a scientific context might be attributed to Carnot, it was probably not until the late 1840s or 1850s that it became common parlance.
2. Nietzsche, F (2003) *The Genealogy of Morals* tr. by Horace B Samuel, 1913. New York: Dover Publications
3. Foucault, M. (1991) 'Nietzsche, Genealogy, History' *The Foucault Reader* ed Paul Rabinow, London: Penguin pp. 76–100
4. Ibid. p. 78
5. *CE* p. 116
6. Moulard-Leonard, V. (2008) *Bergson-Deleuze Encounters, Transcendental Experience and the Thought of the Virtual* New York: State University of New York Press
7. Dreyfuss & Rabinow, eds. (1983) *Beyond Hermeneutics and Structuralism*, Chicago: University of Chicago Press p. 49
8. Kreps, D. (2015) Foucault's Orientalism in His History of Homosexual Identities *Manuscript in preparation*
9. Pepper, S. (1970 [1942]) *World Hypotheses: A study of evidence*, Los Angeles: University of California Press
10. Marcotte, E. (1989) Some Variations on a Metaphilosophical Theme, *International Studies in Philosophy* 21(3) 49–61
11. Ibid. p. 49
12. Ibid. p. 50
13. Derrida, J. (1981) *Positions,* Translated and Annotated by Alan Bass. Chicago: University of Chicago Press p. 32.
14. Pepper, S. (1970 [1942]) *World Hypotheses: A Study of Evidence*, Los Angeles: University of California Press p. 1
15. Foucault, M. (1995) *Archaeology of Knowledge*, London: Routledge p. 117
16. Pepper, S. (1970 [1942]) *World Hypotheses: A Study of Evidence*, Los Angeles: University of California Press p. 342
17. Lovelock, J. E. (1982) *Gaia: A New Look at Life on Earth* Oxford: Oxford University Press
18. Goodwin, B. (1994) *How the Leopard Changed its Spots* New York: Charles Scribner & Sons
19. Dawkins, R. 1989. *The Selfish Gene*. Oxford: Oxford Paperbacks.
20. Marcotte, E. (1989) Some Variations on a Metaphilosophical Theme, *International Studies in Philosophy* 21(3) 58
21. Foucault, M. (1995) *Archaeology of Knowledge*, London: Routledge p. 187
22. Ibid. p. 187

23. Ibid. p. 187
24. Ibid. p. 187
25. Darwin, C. (1859) *On The Origin of Species* An Electronic Classics Series Publication http://www2.hn.psu.edu/faculty/jmanis/darwin/originspecies.pdf
26. Tansley, A. (1935) The Use and Abuse of Vegetational Concepts and Terms. *Ecology* 16(3) 284–307
27. See Hagen, J. B. (1992) *An Entangled Bank* NJ: Rutgers University Press pp. 64–68
28. Ibid. pp. 87–97
29. Spencer, H (1860) *The Social Organism* http://www.econlib.org/library/LFBooks/Spencer/spnMvS9.html
30. Smuts, J. (1926) *Holism and Evolution* https://archive.org/details/holismevolution00smut
31. See Hagen, J. B. (1992) *An Entangled Bank* NJ: Rutgers University Press pp. 84–85
32. Bertalanffy, L. (1933) *Modern Theories of Development: An Introduction to Theoretical Biology* translated and adapted by J. H. Woodger, London: Oxford University Press
33. Bertalanffy, L. (1950) Theory of Open Systems in Physics and Biology *Science* 111(2872) pp. 23–29
34. Bertalanffy, L. (1968) *General System theory: Foundations, Development, Applications,* New York: George Braziller, revised edition (1976)
35. Laszlo, E. (1972) *Introduction to Systems Philosophy: Toward a New Paradigm of Contemporary Thought* NY: Joanna Cotler Books; New edition (Feb 1974)
36. Laszlo, E. (1996) *The Systems View of the World* NY: Hampton Press
37. Foucault, M. (1995) *Archaeology of Knowledge*, London: Routledge p. 188
38. Laszlo, E. (2004) *Science and the Akashic Field: An Integral Theory of Everything* VT: Inner Traditions; 2 Rev edition (1 Jun 2007)
39. Hagen, J. B. (1992) *An Entangled Bank* NJ: Rutgers University Press
40. Golley, F. B. (1993) *A History of the Ecosystem Concept in Ecology* London: Yale University Press
41. Lilienfeld, R. (1978) *The Rise of Systems Theory: An Ideological Analysis* NY: John Wiley & Sons
42. Mirowski, P. (2002) *Machine Dreams: Economics Becomes a Cyborg Science* NY: Cambridge University Press
43. Prigogine, I., and Stengers, I., (1985) *Order out of Chaos: Man's New Dialogue with Nature* London: Flamingo
44. Curtis, A. (2011) *All Watched Over By Machines of Loving Grace* London: BBC
45. Curtis, A. May 29 2011. *How the 'ecosystem' myth has been used for sinister means* London: The Observer
46. Darwin, C. (1859) *On The Origin of Species* An Electronic Classics Series Publication http://www2.hn.psu.edu/faculty/jmanis/darwin/originspecies.pdf pp. 432–433
47. Hagen, J. B. (1992) *An Entangled Bank* NJ: Rutgers University Press p. 2
48. Ibid. pp. 1–2
49. Prigogine, I., & Stengers, I., (1985) *Order out of Chaos: Man's New Dialogue with Nature*. London: Flamingo p. 75
50. Ibid. p. 75

51. Schweber, S. S. (1977) The origin of the *Origin* revisited *Journal of the History of Biology* 10(2), 265
52. Prigogine, I., and Stengers, I., (1985) *Order out of Chaos: Man's New Dialogue with Nature* London: Flamingo p. 69
53. Ibid. p. 70
54. Ibid. p. 60
55. Ibid. p. 60
56. Ibid. p. 60
57. Ibid. p. 66
58. http://en.wikipedia.org/wiki/History_of_the_bicycle
59. http://en.wikipedia.org/wiki/Isambard_Kingdom_Brunel
60. http://en.wikipedia.org/wiki/Elias_Howe
61. http://en.wikipedia.org/wiki/Henry_Bessemer
62. Darwin, C. (1887) The Autobiography of Charles Darwin, Darwin Online http://darwin-online.org.uk/content/frameset?viewtype=text&itemID=F1497&pageseq=69
63. Burchfield, J. D. (1998) The age of the Earth and the invention of geological time, *Geological Society*, London, Special Publications v.143; pp.137–143
64. Phillips, J. (1837) *A Treatise on Geology*, vol. 1. London: Longman, Rees, Orme, Brown, Green & Longman.
65. Gould, S. J. (1987) *Time's Arrow, Time's Cycle* Cambridge: Harvard University Press
66. Darwin, C. (1859) *On The Origin of Species* An Electronic Classics Series Publication http://www2.hn.psu.edu/faculty/jmanis/darwin/originspecies.pdf p. 256
67. Lyell, C. (1830–1833) *Principles of Geology*. 1st edition, 3 vols. London: Murray.
68. Schweber, S. S. (1977) The origin of the *Origin* revisited *Journal of the History of Biology* 10(2), 234
69. Darwin, C. (1859) *On The Origin of Species* An Electronic Classics Series Publication http://www2.hn.psu.edu/faculty/jmanis/darwin/originspecies.pdf p. 278
70. Ibid. p. 262
71. Schweber, S. S. (1977) The origin of the *Origin* revisited *Journal of the History of Biology* 10(2), 234 and 252 (note)
72. Burchfield, J. D. (1998) The age of the Earth and the invention of geological time, *Geological Society*, London: Special Publications v.143; p. 139
73. Hagen, J. B. (1992) *An Entangled Bank* NJ: Rutgers University Press p. 2
74. Spencer, H. (1860) *The Social Organism* first published in *The Westminster Review* for January 1860 and reprinted in *Spencer's Essays: Scientific, Political and Speculative* (London and New York, 1892, in three volumes) http://www.econlib.org/library/LFBooks/Spencer/spnMvS9.html
75. Spencer, H. (1964) *Principles of Biology* Williams and Norgate p444 https://archive.org/stream/principlesbiolo05spengoog#page/n10/mode/2up
76. Smith, Adam (1977) [1776]. *An Inquiry into the Nature and Causes of the Wealth of Nations*. Chicago: University of Chicago Press
77. Gould, S. J. (2002) *The Structure of Evolutionary Theory* Cambridge: Harvard UP p. 59

78. Darwin, C. R. *Notebook M*: [Metaphysics on morals and speculations on expression (1838)]. CUL-DAR125. – Transcribed by Kees Rookmaaker, edited by Paul Barrett. (*Darwin Online*, http://darwin-online.org.uk/) p. 109
79. Ibid. p. 155
80. Darwin, C. R. (1871). *The descent of man, and selection in relation to sex*. London: John Murray. Volume 1 p. 81
81. Höffding, H. (1909) The Influence Of The Conception Of Evolution On Modern Philosophy, in Seward, A. C. ed. *Darwin and modern science. Essays in commemoration of the centenary of the birth of Charles Darwin and of the fiftieth anniversary of the publication of* The Origin of Species. Cambridge: Cambridge University Press p. 448
82. Ibid. p. 460
83. Schweber, S. S. (1977) The origin of the *Origin* revisited *Journal of the History of Biology* 10(2) p. 233
84. Ibid. p. 232
85. Ibid. p. 232
86. Ibid. p. 232
87. Ibid. p. 232
88. Ibid. p. 232
89. Ibid. p. 277
90. Ibid. p. 278
91. Gould, S. J. (2002) *The Structure of Evolutionary Theory* Cambridge: Harvard UP p. 36
92. Schweber, S. S. (1977) The origin of the *Origin* revisited *Journal of the History of Biology* 10(2) p. 240
93. Gould, S. J. (2002) *The Structure of Evolutionary Theory* Cambridge: Harvard UP p. 20
94. Schweber, S. S. (1977) The origin of the *Origin* revisited *Journal of the History of Biology* 10(2) p. 282
95. Ibid. p. 283
96. Hagen, J. B. (1992) *An Entangled Bank* NJ: Rutgers University Press p. 5
97. Spencer, H (1860) *The Social Organism 9.35*
98. Doherty, B. (2008) *Radicals for Capitalism: A Freewheeling History of the Modern American Libertarian Movement*, PA: PublicAffairs. p. 246.
99. *CE* p. xxiv
100. Henderson, L. (1913) *The Fitness of the Environment* Macmillan p312 *http://www.geology.19thcenturyscience.org/books/1913-Henderson-Fitness/htm/doc.html*
101. Hagen, J. B. (1992) *An Entangled Bank* NJ: Rutgers University Press p. 80
102. Foucault, M. (1995) *Archaeology of Knowledge*, London: Routledge p. 187
103. Tansley, A. (1935) The Use and Abuse of Vegetational Concepts and Terms. *Ecology* 16(3) 284–307
104. Although a colleague of his at Oxford, Roy Clapham, is credited as possibly being the first to coin the term, 'in the early 1930s'. Tansley was head of department, and Clapham in the first years of his first post-doctoral academic post. See http://www.nationalarchives.gov.uk/a2a/records.aspx?cat=200-ncuacs89200&cid=-1#-1
105. Tansley, A. (1935) The Use and Abuse of Vegetational Concepts and Terms *Ecology* 16(3), 286

106. Smuts, J. (1926) *Holism and Evolution* https://archive.org/details/holismevolution00smut
107. See Hagen, J. B. (1992) *An Entangled Bank* NJ: Rutgers University Press pp. 84–85
108. Smuts, J. (1926) *Holism and Evolution* p. 226 https://archive.org/details/holismevolution00smut
109. Morgan, C. L. (1923) *Emergent Evolution*, London: Williams and Norgate https://archive.org/stream/emergentevolutio032372mbp#page/n5/mode/2up
Morgan, C. L. (1926) *Life, Mind and Spirit*, London: Williams and Norgate
Morgan, C. L. (1933) *The Emergence of Novelty*, New York: Henry Holt and Co.
110. Morgan, C. L. (1894) *An Introduction to Comparative Psychology* Newcastle: Walter Scott Publishing p58. https://archive.org/details/anintroductiont00morggoog
111. Ibid. p. 58.
112. Morgan, C. L. (1923) *Emergent Evolution*, London: Williams and Norgate https://archive.org/stream/emergentevolutio032372mbp#page/n5/mode/2up p. 1
113. Ibid. p. 40
114. Ibid. see p. 116, p. 148 and p. 166
115. Bertalanffy, L. (1928) *Modern Theories of Development: An Introduction to Theoretical Biology* translated and adapted in 1933 by J. H. Woodger London: Oxford University Press.
116. *CE* p. 133
117. Lilienfeld, R. (1978) *The Rise of Systems Theory: An Ideological Analysis* NY: John Wiley & Sons p. 13
118. Ibid. p. 14
119. Ibid. p. 16
120. Kleene, S. (2001[1967]) *Mathematical Logic*. John Wiley p. 250
121. Mirowski, P. (2002) *Machine Dreams: Economics Becomes a Cyborg Science* NY: Cambridge University Press p. 119
122. Bertalanffy, L. (1928) *Modern Theories of Development: An Introduction to Theoretical Biology* translated and adapted in 1933 by J. H. Woodger London: Oxford University Press.
123. Foucault, M. (1995) *Archaeology of Knowledge*, London: Routledge p. 187
124. See Mirowski, P. (2002) *Machine Dreams: Economics Becomes a Cyborg Science* NY: Cambridge University Press for an excellent guide to this history.
125. https://en.wikipedia.org/wiki/Norbert_Wiener
126. Hagen, J. B. (1992) *An Entangled Bank* NJ: Rutgers University Press p. 71
127. Ibid. p. 71
128. Arturo Rosenblueth, Norbert Wiener and Julian Bigelow, 'Behavior, Purpose and Teleology,' *Philosophy of Science* 10 (1943): 18–24
129. See Joel B. Hagen (1992) *An Entangled Bank* NJ: Rutgers University Press pp. 64–68
130. Ibid. pp. 87–97
131. Hagen, J. B. (1992) *An Entangled Bank* Rutgers University Press, NJ p. 68
132. Mirowski, P. (2002) *Machine Dreams: Economics Becomes a Cyborg Science* NY: Cambridge University Press pp.162–176
133. Ibid. p. 162

134. Ibid. p. 176
135. Ibid. p. 261
136. Ibid. p. 157
137. Ibid. p. 236
138. Hagen, J. B. (1992) *An Entangled Bank* NJ: Rutgers University Press p. 126
139. Odum, H (1959) *Fundamentals of Ecology* (2nd ed) Philadephia: Saunders & Co. p. 44
140. Hagen, J.B. (1992) *An Entangled Bank* NJ: Rutgers University Press p. 132
141. Mirowski, P (2002) *Machine Dreams: Economics Becomes a Cyborg Science* NY: Cambridge University Press p. 147
142. Bertalanffy, L. (1950) Theory of Open Systems in Physics and Biology *Science* 111(2872), 23–29
143. Bertalanffy, L. (1968) *General System theory: Foundations, Development, Applications,* New York: George Braziller, revised edition (1976)
144. Laszlo, E. (1972) *Introduction to Systems Philosophy: Toward a New Paradigm of Contemporary Thought* NY: Joanna Cotler Books; New edition (Feb 1974)
145. Simon, H. (1962) The Architecture of Complexity. *Proceedings of the American Philosophical Society*. Vol. 106(6)
146. Botkin, D. (1992) *Discordant Harmonies* Oxford: Oxford University Press p. 7
147. Turner, F. (2006) *From Counterculture to Cyberculture*. Chicago: University of Chicago Press
148. See Alroy, J. (2008) Dynamics of origination and extinction in the marine fossil record. *Proceedings of the National Academy of Sciences of the United States of America* 105 (Supplement 1): 11536–11542 for a guide to the great mass extinctions in Earth's history. See the IPCC documents for predictions concerning the contemporary loss of species due to climate change: 'There is high confidence that climate change will result in extinction of many species and reduction in the diversity of ecosystems' Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability 19.3.4 Ecosystems and biodiversity, available at http://www.ipcc.ch/publications_and_data/ar4/wg2/en/ch19s19–3-4.html
149. Alvarez L. W., Alvarez W., Asaro F., Michel H. V. (1980) Extraterrestrial cause for the Cretaceous–Tertiary extinction. *Science* 208 (4448), 1095–1108

5
Durée Complexe

This chapter makes a first attempt to map the ideas of Bergson with those of complexity theory – seeking, if you will, a kind of *durée complexe*. Complexity theory is multiple and being explored in many different disciplines.[1] The complex adaptive systems in environmental biology, also known as ecological complexity, will be our focus; but some of the ideas we will need to explore to understand them apply equally well in other fields, too. It will require starting with some background in physics and thermodynamics to grasp the concepts I wish to deal with, in relation to the ideas on life, matter and consciousness that Bergson puts forward in the latter part of his *Creative Evolution*. The chapter therefore falls into two parts: on *durée,* and on *complexe.*

As we have seen – in my own understanding of Bergson's ideas in Chapter 2 of this volume, in the early interpretation of his work by H. Wildon Carr,[2] and in Mullarkey's 1990s interpretation – Bergson's ideas do not constitute a system. Indeed – for Mullarkey at least – Bergson's oeuvre can be said to incorporate a fitting incoherence: a sense that, perhaps in the manner of quantum theory – as we shall see – one might see different things, both in Bergson, and through Bergson's eyes, depending on how one approaches them, and on what the focus of attention happens to be.[3] Addressing an incomplete universe, Bergson's philosophy does not attempt to encompass it nor constitute in itself anything more than an incomplete understanding: a collection of ideas and perspectives rather than an integrated worldview. As Bergson himself put it, 'Unlike the philosophical systems properly so called, each of which was the individual work of a man of genius and sprang up as a whole, to be taken or left, [his own project] will only be built up by the collective and progressive effort of many thinkers, of many observers also, completing, correcting and improving one another'.[4] As we shall see, this remains true, not just for Bergson's philosophy, but – despite all attempts and the enthusiasm that accompanies them – for physics too.

I will not, therefore, be attempting to apply *all* of Bergson's ideas to *all* of physics and complexity theory – if indeed such a thing is possible. I will be focussing principally on Bergson's ideas as laid out in *Creative Evolution*, on Bergson's argument with Einstein and the support for his ideas from quantum physicist Louis de Broglie, and on the complexity theory focused around environmental biology. It will be for others perhaps, hereafter, to make further comparisons: either using more of Bergson's oeuvre or addressing quantum mechanics and complexity theory more broadly, or indeed both. Nonetheless, as will have become clear in the genealogy of systems theory presented in the last chapter, the core concerns of consciousness, space and time, as they are presented by Bergson, underpin an evolutionism that challenges both the mechanistic and organicist aspects of traditional systems thinking in fundamental ways: contextualised in an unfolding duration, one cannot reduce these processes to spatially and mathematically certain equations or axioms; nor are they containable in any holistic totality smaller than that of the entire universe itself, which is itself continually and unceasingly changing and evolving. Similarly, the most common application or location of complex systems – whether mathematical, computational, economic, organisational or purely informational – remain *living* systems, with their evolutionary biology being the key characteristic. I believe, therefore, that the site where the ideas of Bergson and complexity theory best meet is on this very subject.

To undertake this meeting, I will of course have to include ideas on time, matter, perception and consciousness – developed in *Time and Free Will* and *Matter and Memory,* and reprised in *Creative Evolution* – in relation to physics and to complexity theory; for these are key to understanding Bergson's evolutionism. But the thrust of the argument, nonetheless, will restrict itself to discussing how Bergson's understanding of *creative* evolution can inform – and in some cases perhaps further – the understanding of evolution that is emanating from very recent studies in environmental biology.

I will not be attempting to put forward a scientific understanding of the breadth and depth of either physics or environment biology in the late 20th and early 21st centuries – nor, as in the last chapter, a Foucauldian genealogy of it. I have no background in the study of either, let alone such scientific expertise. I will be concentrating upon the ideas of Stuart Kauffman,[5] Brian Goodwin,[6] and to a lesser extent

Daniel Botkin,[7] as three of the principal voices in the field, whose books have made the topic accessible to those from outside the field. To undertake this, I will also have to include some of the ideas of the Belgian physical chemist Ilya Prigogine,[8] whose work informs that of these three environmental biologists – and the first part of this chapter – and who has similarly made his ideas available in accessible form. As Castellani and Hafferty have described, the computational and mathematical skills required to engage in complexity science means most sociologists (for which one might also read philosophers) must '"look in" on complexity science as something strange and wonderful that might benefit their work, rather than looking at it from "within" as something sociology helped to create.'[9]

The broader 'register' of this chapter, then, in contrast to the last, seeks to juxtapose philosophy and science, each in their own terms, rather than approach either or both from a critical perspective. Ultimately, both Bergson's evolutionism, and that of Kauffman, are – in Gould's terms – structural, or formal, placing adaptation as a secondary feature of evolution. Yet for neither of them is such formalism associated with any line of progress, as with the finalist evolutionary theories such as Lamarck's, or divine guidance, such as the emergentism of Morgan. As Kauffman puts it: 'With a sudden visual shift, the background can become the foreground, and the former foreground, selection, can become the background. Neither alone suffices. Life and its evolution have always depended on the mutual embrace of spontaneous order and selection's crafting of that order.'[10] There is, for both Kauffman and Bergson, a primary, spontaneous, driving and organising force, to which natural selection is a secondary adjunct, though that secondary mechanism remains powerful and essential. As Bergson puts it: 'That adaptation to environment is the necessary condition of evolution we do not question for a moment.'[11] Or, as Kauffman puts it, 'natural selection finds its role as the molder and shaper of the spontaneous order for free.'[12] It is the confluence of Kauffman's and Bergson's driving forces that shall be my focus in the second part of this chapter.

In Pepper's terms, one might say that it is the contextualist, historicising approach which, through Bergson and Kauffman, is overcoming the composite of mechanist and organicist approaches. If the agents of evolution are no longer exclusively individuals competing and struggling with one another, in the Smithsonian/Darwinian formulation, but that such adaptationism merely moulds and shapes the fruits of a more primary force, which drives evolution as a constantly interpenetrating and interweaving creativity among collectivities, then everything comes down to context, both environmental and historical: everything becomes contingent and the individual ceases to be an island.

Bergson's own work deals consistently – and famously – with dualities, dichotomies, and oppositions. In keeping with this approach, then, my own discussion of the confluences between Bergson's evolutionism and the scientific ideas of contemporary evolutionary biologists will also – nonetheless – incorporate, at appropriate moments, poststructuralist interpretations of the ideas of complexity theory, such as those introduced by Paul Cilliers,[13] and some Deleuzean, Derridean and Foucauldian insights too. The Bergsonian roots of poststructuralism already discussed in Chapter 3 of this volume come more closely into play here, along with the 'register' of Chapter 4's critical genealogy, enabling, I hope, a truly novel interpretation of how the contemporary notion of complexity might be improved – for both the lay reader and scholar alike – through exposure to the ideas, and legacy, of Bergson's philosophy.

The chapter is organised as follows: we must begin, in the first part, with the scientific understanding of time. This is the story of how the evolution of thermodynamics would ultimately come to challenge the reversible concept of time in classical dynamics; and the story of Einstein, Hubble and Planck, and of how both astrophysics and thermodynamics introduced irreversibility next to, and in some ways in contradiction to, both classical and Einsteinian dynamics. Here, with the new quantum physics of Planck, Bohr, Heisenberg, Schrödinger and Louis de Broglie, we will see how Bergson's panpsychistic universe of Time, Life and Matter not just reflects, but in many ways conceptually presages the revelations of this new physics, and how durational succession is key to a proper understanding of the universe in both quantum theory and *durée réelle*.

Consciousness, as we will see, is key to durational succession, and the indetermination it implies re-inserts human freedom and choice into the unfolding of the universe for the first time since Descartes banished it from the mechanistic world his dualism created. Consciousness, too, soon encroached also into cybernetics, in its second wave, which understood – as had quantum uncertainty – that one simply cannot ignore the observer in any system. These insights into how Bergson's conscious universe map onto the new physics and how cybernetics evolved out of its closed automaton circuits then lead us into the new science of complexity, with Bertalanffy's open systems, and the complex evolutionism of Kauffman and Goodwin.

Bergson's key ideas: *intuition, durée réelle,* matter and perception, and the *élan vital,* 'map' onto the key ideas of complexity theory: autonomous agents, emergence, attractors, the 'shortest description,' and order at the edge of chaos. The 'fit' between these two sets of ideas is sometimes close, sometimes revealing, and my task in the second part of this chapter is both to describe the ideas of complexity, and to show their linkages to Bergson's thought. Nonequilibrium conditions in evolutionary biology and ecology, and in thermodynamics, will figure significantly.

Exploring the mechanisms of complex adaptive systems in the origin of life at the interface between the inert and the living, we will examine how the notion of the 'shortest description' maps onto the *durée réelle,* and how the flow of perception/matter/intuition reveals perception as far too complex an interaction to divide into subject and object, as Cilliers makes clear. The *élan vital,* finally, will then show itself to us in new garb, as the emergence and self-organisation of complex adaptive systems in evolutionary environments, with Bergson's notions of tendency mapped onto the concept of attractors that bring order at the edge of chaos. Bergson's divergent *élan vital* we will see, at last, as Kauffman's explosive emergence.

We will then conclude our exploration of these ideas in the final chapter, with a consideration of the human *niche*: how the urban environment and our human geography have, under the influence of individualism, brought about climate change, and how an undeniable 'human exceptionalism', by dint of our sheer – and lately catastrophic – impact upon our environment, cannot be ignored. We will recall, in considering the 'conquest of the social', Bergson's imagery of ants and human societies, and of the great hope for 'open' societies outlined in *Two Sources of Morality and Religion*.

On *durée*

One of the key concepts in complexity theory, *emergence* – and, of course, Bergson's own notion of the *durée réelle* – depends fundamentally on an understanding of time as *irreversible*, and of the fundamental nature of durational succession. This is in contradiction to much traditionally reductionist thinking in the classical physics community – for which, as we have seen in the last chapter, time is a *reversible* property of relations of force and equivalences of energy and matter (Newton's Laws of Motion), and the succession of past, present and future are erased in what becomes, thereby, a predetermined, 'given' universe – albeit only visible to Laplace's demon. For Bergson, such reversibility is possible, as we saw in Chapter 2, only because such relations and equivalences are represented spatially, and the time that is being considered is in fact a spatial conception and not *real time* at all. Yet, in the strictest scientific terms too, this reversibility is something that, at various levels and in various contexts, has had to be discarded in order that a clear scientific understanding of what is really going on can unfold. There are now so many such contexts that an overall scientific reassessment of time is long overdue. Ilya Prigogine has been one of the primary voices in recent decades in the scientific community for such a reassessment of time, and the complexities of irreversibility; and I will, in this section, make much use of his arguments, as well as those of other commentators on the relationship of Bergson's ideas with the new physics.

Irreversibility, in fact, has been around for quite a long time in scientific circles, in the form of thermodynamics. We have already come across Carnot, whose work on thermodynamics in the 1820s led him to use the word 'system' for the first time in a scientific sense. Carnot's ideas, however, already had antecedents. It was in fact Fourier who, in 1811, won the French Academy of Sciences prize for his mathematical description of the propagation of heat in solids: in short, 'heat flow is proportional to the gradient of temperature.'[14] It is a simple law, and applies to all matter whether solid, liquid, or gaseous – at least, at the macroscopic level. For Prigogine it is nothing less than the first break with Newtonian mechanics, the moment when 'mathematics, physics, and Newtonian science ceased to be synonymous.'[15] In France, under the presiding positivist Auguste Comte – whose positivism also influenced Darwin – the study of heat was placed alongside the study of dynamics: along with the mechanical equilibrium of the ordered universe science was set the task of understanding thermal equilibrium too – hence Carnot's notion, in 1824, of a 'system', the 'Carnot cycle', in which thermal energy and work achieved can be converted into one another, and, thereby, constitute an equilibrium.

In Britain, however, the science of heat took another turn: as Prigogine dubs it, 'the theory of irreversible processes'.[16] Barely a decade or more after Laplace had published his deterministic ideas on chance and probability – which are based on the deterministic mechanisms of classical mechanics – thermodynamics, and its irreversible processes, was challenging his demon.

Where classical dynamics concentrated upon the position and velocity of the *constituents* of a system, the study of heat focussed upon a set of *macroscopic parameters* – temperature, pressure, volume, etc. – and the boundary conditions that describe the relation of the system to its environment. Measuring these parameters and conditions required a new concept. During the early 19th century the concept of 'energy' evolved gradually, through the studies of biochemists such as Galvani, who produced the first experimental 'electric current' with a frog's body. Volta was then the first to describe these 'galvanic' contractions as an 'electric current', and then he reproduced it with chemicals alone. Oersted then demonstrated the magnetic properties of such currents.[17] The relationship between magnetism and electricity was outlined by Faraday, in 1831, and then in 1847 Joule came up with the concept of *conversion* – the idea that '"something" is quantitatively conserved while it is qualitatively transformed.'[18] The quantity conserved was called 'energy'.

This rule of the conservation of energy offered 19th century physicists a unification of the whole of nature, and arguably forms the basis of Einstein's later work. But energy conversion, as Prigogine points out, 'is merely the destruction of a difference, together with the creation of another difference.'[19] Crucially, in all these processes where heat is created, it is fuel that is irreversibly destroyed. The process of cooling cannot reconstitute the coal that was burnt. The equivalences on paper conceal the reality of such destruction.

Returning to Carnot, we must remember that, like all his contemporaries in the 1820s, he assumed that mechanical and thermal engines must be similar. Working in the disciplinary silos established by Comte it was Carnot's understanding that the ideal heat engine, 'instead of having to avoid all contacts between bodies moving at different *speeds*, will have to avoid all contact between bodies having different *temperatures*.'[20] This ideal Carnot cycle is of course rather tricky – attempting an exchange of heat between two bodies that cannot come into contact. No mention is made at any point of the furnace in which the coal is burning, and the permanent loss of the fuel that is consumed whilst creating and maintaining the temperature differences. As an exercise in blinkered thinking it is quite extraordinary.

So, following Joule's late 1840s insights, in 1850 Clausius was able to combine the Carnot cycle with the notion of the conservation of energy. Thermodynamics was properly established, linking mechanical and thermal effects through conversion of heat into work. Clausius' 1850 cycle remains as ideal as Carnot's, but the 'losses' in the cycle – the requirement for fuel to be burnt to reduce the temperature in a body whose temperature has been raised by burning fuel – was now included. Based on these notions – and inspired, as we saw in the last chapter, by Joule's retelling of the work of Carnot and Clapeyron – William Thomson

(Lord Kelvin), in 1852 finally formulated the now famous Second Law of Thermodynamics: 'the existence in nature of a *universal tendency* toward the degradation of mechanical energy.'[21] Here was a scientific refutation of the eternal, ideal perpetual-motion machine most physicists at that time conceived the universe to be. The world of Kelvin's tendency to degradation is 'an engine in which heat is converted into motion only at the price of some irreversible waste and useless dissipation.'[22] This one-way tendency creates a very different world to that of the perpetual-motion machine maintaining perfect mechanical equilibrium: thermal equilibrium, in this world, is 'heat death' – the end of all differences of temperature, and of all mechanical effects.

Here we must remember that, in geology as well as physics, during the early 19th century, the concept of time was becoming all the more important: as we have seen in Chapter 2, with Lyell's notion that the Earth was not created *as is,* but had *evolved* over millions of years – later to be understood as billions – and through multiple changes. Similarly, as Darwin was to assert in 1859, the flora and fauna living on the Earth had likewise *evolved* rather than simply appeared as they are now. So Clausius' 1865 development of Kelvin's ideas into the concept of *entropy* – the irreversible dissipation of energy – and its implications for a historical cosmology, was in keeping with developments across the sciences of the mid-19th century. The ideal systems of Fourier and Carnot, and of Clausius' own earlier 'conservation of energy' – applied, in the 1860s finally, to *real* engines – had had to account for all the irreversible processes inside such systems: the destruction of fuel, the waste, the heat losses, friction, and so on. Crucially, it was clear that such 'entropy production' cannot be reversed. It always goes in the same direction.

From this point on, classical dynamics and thermodynamics proceeded in separate academic departments, with distinct progress and little communication between the two. Einstein would crown the former, quantum physics the latter. For the rest of the 19th century classical dynamics remained the overarching theme for all academic science and engineering alike, and the inconvenient truth of entropy by and large stayed put in the study of thermodynamics. It took the extraordinarily creative advances in scientific understanding of the early decades of the 20th century to move beyond the settled view of most scientists – of balanced forces that are reversible, with a reversible time. What emerged, as the 20th century unfolded, was a new appreciation of the universe at three different levels: the *macroscopic* level, with which we are familiar, and for which Newton's dynamics continue to describe a good deal of what we observe more or less adequately; but also a *cosmic* level, in a universe that turns out to be far larger and far stranger than was ever imagined before; and a *microscopic* level, in the even stranger world of quanta at the sub-atomic scale.

Einstein's theories and equations helped us understand much more deeply than Newton's the nature of the *macroscopic*, and some of the strangeness of the *cosmic* levels. But astrophysicists such as Hubble soon proved Einstein's rather Newtonian belief in a reversible simplicity to the universe unfounded; then the quantum theorists such as Planck and Heisenberg showed how at the *microscopic* level only probabilities could be adequately described, in a world where not only Newton's, but even Einstein's theories and equations break down. At issue, in the end, is that reversible time and irreversible time are two different things. As we have seen, through examining Bergson's concept of the *durée réelle*, reversible time is in fact a series of spaces in juxtaposition. Irreversible time, by contrast, is something else entirely, for which there has been, in science, no concept at all: for Einstein, indeed, it was, wherever possible, paramount to discount it.

Early in his career, Prigogine realised science (except thermodynamics) simply does not really deal with time: 'This surprise could have led [the scientist] to two attitudes, both of which we find exemplified in the past: one would have been to discard the problem, since classical science seemed to have no place for time; and the other would have been to look for some other way of apprehending nature, in which time would play a different, more basic role.'[23] Prigogine acknowledges, immediately, that great philosophers in the early part of the 20th century tried to wrestle with this issue: including Bergson, for whom he has warm words. As he says, 'For Bergson, all the limitations of scientific rationality can be reduced to a single and decisive one: it is incapable of understanding *duration* since it reduces time to a sequence of instantaneous states linked by a deterministic law.'[24] It is clear to Prigogine that, for all that the project of *intuition philosophique* may not have materialised (at least not in Prigogine's chemist's eyes, though some poststructuralists might disagree), Bergson 'has not failed in that, unlike Hegel, he had the good fortune to pass judgement upon science that was, on the whole, firmly established – that is, classical science at its apotheosis, and thus identified problems which are indeed still our problems.'[25]

Prigogine's principle contribution to thermodynamics was in predicting the behaviour of open systems weakly driven by external energy sources. Interestingly, Jarzynski and Crooks[26] have since – very recently – taken this further, showing that the entropy produced in a thermodynamic process can be described by a simple ratio: the probability that the atoms will undergo a process divided by the probability of their undergoing the reverse process. In other words, as entropy production increases, so does this ratio: a system's behaviour, as the ratio increases, becomes more and more 'irreversible'.

Now, the static time of classical physics and the existential or psychological time we experience in our lives have been in opposition at least since Kant. Yet it was when classical science reached that apotheosis – perhaps no more so than in the person of Albert Einstein – that it met the need for change. I speak, of course, here, once again, as a layman, not privy to the lofty mathematics with which physicists conduct their work.[27] Nonetheless, I may take Prigogine's lead, and, winner of the 1977 Nobel Prize for his work on the thermodynamics of nonequilibrium systems, he is privy to much of this scientific understanding, and our environmental biologists have warm words for his conceptual breakthroughs.[28]

On Relativity, and its challengers from the cosmic and the microscopic

As Prigogine relates, then, in his book co-authored with Stengers, Einstein's General Theory of Relativity was revolutionary when it was published. Newton's equations accurately describe gravitational effects here on Earth, but at very much larger scales these Newtonian equations fail. General Relativity makes much more accurate predictions, and illuminates the famous Einsteinian unity of space and time: a space-time fabric that curves and warps when matter is present. But this Einsteinian universe, as Prigogine reminds us, published in 1917, was immediately challenged by astrophysicists, such as Friedman, Lemaitre, and Hubble, whose observations and calculations revealed, not a static but an *expanding* universe. 'For many years physicists remained reluctant to accept such an "historical" description of cosmic evolution. Einstein himself was wary of it.'[29] The universe was conceived by Einstein and his followers as static – more or less the same throughout eternity.

Yet, just as looking at the sky had brought about the Newtonian science of classical dynamics in the first place, the irreversibility of time that seems to contradict the balanced order of such a static universe is most apparent in the sky – as we have come to know since Hubble. There we see all the galaxies of the universe moving farther and farther away from each other, and 'strange objects: quasars, pulsars, galaxies exploding and being torn apart, stars that, we are told, collapse into "black holes", irreversibly devouring everything they manage to ensnare.'[30] The most fundamental implication of the expanding universe, of course, is that the space-time conceived of by Einstein has a *history* – and therefore a beginning. From this the concept of the Big Bang, and the singularity from which space-time began, emerged. Irreversibility, in short, is absolutely fundamental at the *cosmic* level.

At the *microscopic* level, Einstein's ideas were also soon to be challenged. Born of the Newtonian programme that reduced all physiochemical phenomena to the action of forces – famously encapsulated in Einstein's own equation, $E = mc^2$, which reduces all matter and all energy to a mutually conditioning given related to an unchanging speed of light – there was a deep conviction in both Einstein, and many physicists of his day, that there was a 'fundamental, simple level in nature'.[31] Trying to access this level experimentally, however, was becoming more and more untenable. Indeed, as we saw in Chapter 2, even as Einstein and Bergson began to argue publicly about the nature of time, Duhem was introducing the position known today as 'instrumentalism', acknowledging that the 'unobservables' in sub-atomic physics make a fundamental, simple explanation of the universe as beyond reach as the mythical and philosophical explanations ever were.[32] The only 'simplicity' in the universe exists, in short, at our *macroscopic* level.

Beyond General Relativity, at the *microscopic*, or quantum level, physicists were rapidly discovering new things in the early decades of the 20th century about sub-atomic particles. As we learned from Planck, and later de Broglie and others, such 'particles' in fact often behave like waves. The moment you have a wave you have duration – a wave unfolds, and can only exist in time: matter, in short, ceases to be static, and objects cease to be discrete – precisely as Bergson had characterised them. Heisenberg and Schrödinger, moreover, showed us how these wave particles can potentially be in several places at once, defying all the laws of motion and reversibility in 'wavefunctions' of probability.[33] In this world of quantum theory, the 'unobservables' are described as such because the very act of observing them changes their position, their mass, their frequency, their wavelength – the very things Newton and Einstein would use to understand them. Beyond our direct observation – beyond the possibility of direct observation – the world of quarks, leptons, muons, and other quanta is a fuzzy world of probabilities, imputed from massive experiments in vast underground colliders and intensely complicated mathematical thought experiments. Trying to apply Einstein's General Relativity Theory to extremely small objects just gives us nonsensical answers. However, quantum field theory cannot explain gravitation either. So, these two theories – relativity and quantum – are useful; but they are, from the point of view of physicists searching for a unified field theory, either incomplete, or requiring a whole new approach other than field theory.

A Bergsonian view might be to suggest that the universe is ongoing, and therefore incomplete; thus, a philosophy – like Bergson's – could not completely explain it; nor should the physical sciences be surprised that such completeness eludes them. Black holes are perhaps a case in point. For all that relativity predicts their existence – and both theories have ideas on what might transpire at the event horizon at the perimeter – neither quantum mechanics nor general relativity can explain what actually happens inside a black hole!

The principle point of this – necessarily brief – introduction to the development of modern physics is that the universality of Newtonian mechanics, the idea that it could be applied to everything, broke down with Einstein's, Hubble's, and Planck's theories. The universal constants – Einstein's speed of light, for example, and Planck's *h* – change the Newtonian universe into something much stranger.

Let us look a little closer at each of these breaks with the Newtonian universe: in turn, at the *cosmic,* and then at the *microscopic* levels.

On the speed of light, and Einstein's great debate with Bergson

That the speed of light is a universal – *cosmic* – constant may seem today to be a commonplace, but the implications are profound. The energy an object has due to its motion is called its kinetic energy. At high 'relativistic' velocities, the faster an object moves, the more kinetic energy it has, and the more relativistic mass it gains. Eventually, an object cannot gain any more kinetic energy because it becomes too massive to move. The precise speed at which this happens is the speed of light, which is why, as Einstein explains, no object can move faster than the speed of light. Space, instead, curves and warps to accommodate this universal constant. Space and time – in Einstein's Special Theory of Relativity, from which the more General Theory was derived, moreover – are not the same for all observers, depending on their own *relative* velocity. If the perceptions of observers in any frame of reference are necessarily relative, then absolute space, absolute time, absolute motion and absolute rest cannot exist. Newton's mechanical universality breaks down. In this relative universe, perceived distances are a function of time, perceived times are a function of distance, and neither can be considered an 'independent variable.'

In many respects, Bergson's own conception of time – as inextricably interwoven with matter, with space, in his concept of the *durée* *réelle* – shares much of the thrust of Special Relativity's break with the Newtonian mechanics that dealt in such absolutes and treated time and space as independent variables in calculations of dynamics. Indeed, Bergson was effusive in his praise for the Special Theory of Relativity. However, there arose quite a public controversy between Bergson and Einstein concerning the Special Theory of Relativity, as explored in Bergson's book *Duration and Simultaneity*. It is important to address it, albeit briefly, in this discussion of the irreversibility of time. It hinges, in essence, on whether a philosophical understanding of time, such as Bergson's, is allowable in the worldview of Einsteinian physics.

Taken up by Deleuze, in *Le Bergsonisme,* the argument between Bergson and Einstein is characterised as a distinction between two different interpretations of the concept of multiplicity: Bergson's own, and that of the 19th century mathematician, Riemann, whose curved geometry underpins Einstein's notion of curving space-time.[34] Riemann posited two kinds of multiplicity, or 'dimensional manifolds', in his geometry. (Examples of dimensional manifolds are the two-dimensional, such as a square on a piece of paper, and the three-dimensional, such as a cube.) Riemann's distinction between *discrete* and *continuous dimensional manifolds (*or *multiplicities)* has the former (discrete) containing its own principle of measurement, and the latter (continuous) requiring an external principle of measurement.[35] Bergson's argument, for Deleuze, is about this definition of the latter *continuous multiplicities* – in particular, their 'measurement.' For Deleuze, such continuous multiplicities are located within Bergson's theory of the *durée réelle*. Discrete multiplicities are then to be regarded as differences in degree (susceptible to measurement, material, quantitative), and continuous multiplicities as differences in kind (not susceptible to measurement, durational, qualitative).

The example of relative time, between a traveller moving at the speed of light and his twin waiting at home, is a case in point. In brief, the real time experienced by the observer-traveller, for Bergson, regardless of his relative motion, is not altered. Thus, the experience of time the traveller has is unaffected by his own motion, and similarly that of his twin. Bergson's argument is that the theory of relativity creates a universe that is relative to the observer, and that the motion and time dilation of the 'other' relative to one's own position is experienced by *both* the traveller *and* his twin. The 'difference' in time is *imputed* to the other from the standpoint of either, not *experienced* by the other, who is himself, as an observer, experiencing the universe relative to *him*.[36] This concentration upon the *relativity* of physics allows Bergson to assert that, from the perspective of physics, the time dilation effects of the two twins – described by the physicist – are understood only from the viewpoint of one point of reference. For the philosopher, who understands that there are in fact two points of reference, the paradox dissolves. The British philosopher of science Herbert Dingle[37] was another proponent of this view.[38]

For Deleuze, that there then appear to be multiple experienced times still does not refute Bergson's notion of duration, of the *durée réelle*, if duration itself is understood as a continuous multiplicity. If there are no absolute motions, absolute spaces, absolute times or absolute rests, then there are also no absolute simultaneities. An absolute simultaneity implies a commonly shared instant of time. As I pointed out in Chapter 2, the notion of the *durée réelle* implies that we can never experience an 'instant' of duration: such instantaneous states are derived from the physicists' spatialisation of time. On the contrary, the past and the future, the before and after, are intertwined and interpenetrating: the future always unpredictable, made up of tendencies toward change. The present is in many senses already the past, as Bergson stresses in *Matter and Memory* when considering the myriad messages of perception as they reach the brain.[39] In this sense, in Deleuze's view, our experience of duration is already multiple, as well as continuous. Thus, Bergson's argument with Einstein, at the level of Riemann's continuous multiplicities, not only allows for, but presupposes both an experiential unity *and* a relative range of differing personal experiences of time in the observer-travellers of Special Relativity. Indeed, Bergson argued that the theory of relativity actually presupposes the existence of the *durée réelle*.[40]

The assumption, since their famous public debate on this issue, that Einstein 'won' and Bergson 'lost,' depends, therefore, on one's point of view. Certainly, for the physics community the philosopher was 'seen off' and regarded as having simply not understood the physics of Relativity Theory properly. This assumption usually hinges on this discussion of the 'twin paradox' – where relativity theory would suggest that a twin who had travelled at close to the speed of light, when returning to meet his sibling, would find that they were no longer the same age. Bergson was widely reported to simply deny the 'twin paradox'. But as we have seen, this was not the case. According to Canales, who has written an interesting history of this debate, this was definitely not the case: rather, Bergson fully acknowledged that the travelling twin would be younger and the clock would show an earlier time – continuous multiplicity; he simply disputed the conclusions drawn about *time* from this fact, as we have seen above. As Canales reports, in fact Bergson 'never acknowledged any such defeat. In his view, it was Einstein and his interlocutors who did not understand *him*.'[41]

For Canales, the debate in fact circles around profound *political* disagreements between Bergson and Einstein, surrounding the branch of the League of Nations Bergson was (as we saw in Chapter 1) then leading in an attempt to show that intellectuals could work together at an international level: the International Commission on Intellectual Cooperation (ICIC). At first very reluctant to join, then almost as soon as he had done so very publicly resigning, in 1922 Einstein turned his disagreement with Bergson into an international incident, as part of his rise from a mere physicist, to the physicist-philosopher of international fame and acclaim he remains to this day. For Einstein, this very public spat was about the exclusion of philosophy from an understanding of time – as he said in 1922, 'the time of the philosophers does not exist, there remains only a psychological time that differs from the physicist's.'[42] In this manner, Einstein was deliberately pushing forward his belief in the fundamental, simple level of the universe that in fact depended on his highly restrictive understanding of the nature of time, and dismissal of philosophy's role in any consideration of it whatsoever. But of course, 'physiologists, psychologists, and astronomers…had long known that perceptions of simultaneity differed from physical simultaneity. Legend had it that most scientists had learned this lesson as early as 1795. Relativity, in this respect, had only rediscovered what had already been known.'[43] Bergson's objection was not to the physics of Einstein, but to the encroachment of physics into the realm of philosophy, something which Einstein was clearly attempting to do.

Both men accepted the essential difference between psychological and physical conceptions of time; but – as we have seen – they drew very different conclusions. For Bergson, this difference makes the philosopher's task all the more interesting and relevant: not even physicists can: 'avoid the problem of relating time back to psychology. Every time humans "read an instrument", psychological riddles'[44] reappear. Einstein, however, never accepted this.

So, Bergson did not deny the physics of Einstein's depiction of spacetime; Einstein denied that philosophy had anything to say about time, and the relation between physical and psychological time – particularly with regard to observation.

On Bergson and quantum theory

Here, with another of the universal constants that breaks the Newtonian universe – and indeed Einstein's equations – we come to the *microscopic,* and to Planck's constant, *h*. Einstein still wanted to achieve 'a "complete" deterministic description'[45] of the universe, and was very uncomfortable with the probabilities that quantum theory deals with. Famously, he once said, 'I shall never believe that God plays dice with the world.'[46] He was extremely reluctant to accept the idea that the universe functions ultimately from a set of probabilities. Quantum physics, however, discovered that it does.

Planck, pushing thermodynamics into a whole new science in 1900, examined the behaviour of what are known as 'black bodies'. When objects are heated, they start to emit radiation – at first in the red spectrum: they become red hot; then the white, and so on. An ideal, perfect emitter of heat radiation is a perfect black, emitting only 'black-body' radiation. The spectrum of black-body radiation is determined only by the temperature – because it is so hot – and not by the shape or composition of the black body. What Planck discovered in this thought experiment with black bodies was that, when trying to calculate the very, very small amounts of energy a black body might emit, one could not assume a simply arbitrary amount of energy. Analogous to the currency of a nation state, there exists the smallest coin that is in circulation, and this smallest amount that one might in practice be paid is called, in Planck's law, the 'quantum' – Greek for 'how much'. What Planck discovered was that calculating quanta of energy, not just with black bodies but in general, could be determined by a constant, which is usually written as *h*. Planck's constant, multiplied by the momentum of a sub-atomic particle, gives us the wavelength of that particle when it is behaving like a wave. It is a constant, regardless of the charge or size of the particle, and like the speed of light is quite counterintuitive to our normal understanding. It breaks our image of the atom as a tiny planetary system. The microscopic world suddenly starts to behave – like the expanding universe of the cosmic scale – in ways that almost defy imagination, and make no sense on the macroscopic scale of the everyday.

In this fuzzy world of statistical probabilities, moreover, the act of measurement changes what is measured. Observation, by a human being, through the use of instruments, determines what is observed. By measuring, for example, what is conceived as a reversible and continuous evolution in Schrödinger's equations, the wave function being measured is reduced to an irreversible and discontinuous state at the time of the measurement.[47] At this scale, then, the reversible is unobservable, the irreversible all that experimental science can empirically prove. The mathematical equation, moreover, is unable to describe the irreversible and only able to describe the unobservable reversibility.

Bergson, almost presciently, seemed to understand this long before the physicists were discovering it. As early as 1896, in *Matter and Memory*, Bergson had proposed that matter should be viewed as comprised of '*Modifications, perturbations*, changes of *tension* or of *energy*, and nothing else.'[48] As we saw in Chapter 2, Bergson's universe is comprised of 'numberless vibrations, all linked together in uninterrupted continuity, all bound up with each other, and travelling in every direction like shivers through an immense body.'[49] By 1907, in *Creative Evolution*, Bergson asserted that 'The more physics advances, the more it effaces the individuality of bodies and even of the particles into which the scientific imagination began by decomposing them: bodies and corpuscles tend to dissolve into a universal interaction.'[50] For Bergson, firstly, objects cannot be simply located, because as part of the flow of energies that connects perception and action they should be considered as interactions, as a flux; in later parlance – to be waveform. Secondly, indetermination becomes a fundamental feature of all micro-events: because the nature of durational succession requires it. Let us examine in turn these two aspects of how Bergson's ideas chime with those of quantum theory.

Firstly, the statistical laws and probabilities of quantum theory, at the *microscopic* scale, as we have seen, reject the determinism of Cartesian mechanism. Louis de Broglie, the quantum physicist best known for asserting in 1924 that, not just photons, but all matter has wave properties, as well as particle properties, believed Bergson had valid arguments to make, and could be regarded as having intuited many of the discoveries of the later quantum physics. For de Broglie, it was no exaggeration to hold that in Bergson we find Heisenberg before Heisenberg, Bohr before Bohr. Speaking of *Time and Free Will,* de Broglie says: 'this essay, its author's doctor's thesis, dates from 1889 and consequently antedates by forty years the ideas of Niels Bohr and Werner Heisenberg on the physical interpretation of wave mechanics.'[51]

Writing in the 1940s, before Bergson's reputation had become eclipsed, Louis de Broglie found that Bergson 'anticipated certain essential features of contemporary physical theories,' not just concerning the spatialisation of time, but – more pertinently for quantum physicists – concerning the spatialisation of matter: the idea that matter (in a conception as old as the ancient Greeks, visible to Laplace's demon alone) can be 'represented as an aggregate of discrete, static particles having absolutely precise locations.'[52] As we have seen, for Bergson, matter is better conceived as part of a flow, of a mobility, and it is only the geometry of our thinking that fixes objects in specific spaces. Quantum physics agrees. Werner Heisenberg's famous 'uncertainty principle', indeed, gave us the dictum at the sub-atomic scale, 'that the position and velocity of a particle cannot be simultaneously determined [and that] although either can be measured to any degree of precision, the more accurately one is measured the less accurately the other will be known.'[53] Niels Bohr's principle of complementarity, moreover, 'which states the irreducible duality of wave and particle,'[54] similarly recalls Bergson's own assertions on how durational intuition and intellectual spatialisation give us two very different views on the same things, both of immense importance to our life in this universe.

Of course, de Broglie is not suggesting that one can identify 'the precise statements of quantum physics with the profound, but often vague and fleeting, intuitions of the celebrated thinker. The analogies exist nonetheless.'[55] De Broglie points out that, although Bergson is most famous for, and devotes much more of his work upon, the problem of time, with respect to the geometrical approach to it in common scientific parlance, nonetheless he also addresses space in similar manner. As de Broglie tells us, of the spatialised conception of time common in mathematics and physics:

> Nothing prevents us in this abstract representation from supposing that we may reverse the course of time, contrary to the most certain property of real duration. Nothing prevents us either, as Bergson has well noted [(CE 368)], from supposing that the flux of time operates with an infinite speed, so that the entire past, present, and future history of the world might be found instantaneously spread out before us. It is really such a representation, basically at variance with all the immediate data of our experience, which appears in relativity theory when it invites us to represent the totality of events past, present, and future in the framework of an abstract four-dimensional continuum, space-time. [56]

In such a universe, of course, all events are somehow 'given,' *a priori*, and simultaneous in their particular section of space-time, and 'it will only be through a sort of infirmity of our means of perception that we will discover them successively in the course of our own duration.'[57] Bergson's rejection of this is celebrated by de Broglie, who quotes his assertion that relativity 'takes account neither of what is essential to *succession* nor of *duration*, insofar as it flows. It has no other sign for expressing the succession and the duration which strike our consciousness.'[58] Yet, as Bergson insists, 'succession exists, I am conscious of it; it is a fact.'[59] As de Broglie says, it may indeed be the case that 'the schematic representation of time employed by classical science and pushed to its extreme consequences by relativity theory may be a useful but fallacious schema, which masks for us a part of the real character of the flow of things.'[60] It is clear, moreover, that for space, for 'extensity,' the same applies.

De Broglie is not complementary about *Duration and Simultaneity*. He understands why Bergson wrote it – for relativity theory 'pushed the spatialisation of time and the geometrisation of space to their extreme limits, because it is from this point of view the final development of classical physics.'[61] But, as de Broglie points out, relativity physics is not the last word in science, and more importantly, the 'theory of relativity now appears to us as simply a macroscopic and statistical view of phenomena: it describes things approximately and in bulk,'[62] and does not descend profoundly enough into elementary processes. For that, theories 'stranger than that of relativity'[63] were needed, and indeed, for de Broglie, there is much more accord here with Bergson's ideas. 'Is there any analogy between Bergson's critique of the idea of motion and the conceptions of contemporary quantum theories?' de Broglie asks. 'It seems that the reply ought to be in the affirmative.'[64] Recalling Bergson's repeated reference to the paradoxes of Zeno (de Broglie seems to like the one about the arrow more than that about Achilles and the tortoise) he reminds us that, for Bergson, the spatialisation of movement – the idea that there are a number of points on a line, or trajectory – misses the actual dynamism, the real movement itself. In light of Planck's constant, and Heisenberg's uncertainty relations, at the *microscopic* scale it is impossible to know in detail both the dynamic aspects of elementary processes and their spatial localisation. At the *macroscopic* scale, then, our senses can give us 'the *illusion* of simultaneously knowing the position and momentum of a particle'[65] so that we can then attribute to it a trajectory, and on that trajectory, at each instant, it will possess a certain speed. But as de Broglie makes clear this can only be an approximate image and, 'if we can analyze things more precisely by measuring positions with more precision, we can now grasp only a succession of localisations between which the motion will escape us.'[66] Bergson's understanding, then, that only static positions can be ascertained when studying movement with precise measurement, seems to be supported by quantum theory: 'If one attempts to localize the moving object, through a measurement or an observation, at a point of space, one will obtain only a position and the state of motion will entirely escape.'[67] Wave mechanics, then – able to fix the position of a particle without being able to know its dynamic properties, and able to understand the dynamic properties of a wave without being able to know much about its localisation – seems in keeping with Bergson's critique of macroscopic, classical physics' appreciation of motion: measuring points in space along a trajectory effaces the movement.

So, certainly for de Broglie, the ideas of Bergson on time and space, and on the nature of mobility, are very much in tune with the discoveries – after Bergson's major publications – of quantum mechanics. More interesting still, however, the second point on which Bergson's ideas and quantum theory find consonance is the parallel between the statistical probabilities of wave mechanics (or 'microphysical indetermination') and Bergson's ideas concerning the role of indetermination in the universe, in contrast to the predetermined nature of both the mechanistic and the finalist worldviews. As de Broglie tells it:

> According to the new concepts of physics, when an experiment or an observation makes it possible to define the state of a particle at an instant t_1 with all the precision that Heisenberg's uncertainty relations permit, wave mechanics is in a position to announce what will be the particle's possible locations at a succeeding instant t_2 and their respective probabilities; but it can not generally make definite predictions, and it is in thus substituting for the definite predictions of the older mechanics simple probabilities referring to diverse possibilities, that quantum mechanics finds itself renouncing the rigorous determinism of classical physics. If now, at the instant t_2 which follows t_1, an experiment or observation permits us to precisely locate the particle, the situation changes completely for us, since it is one of the possibilities and no other which is realised. Thus in quantum theory far more than in classical theories, time seems to produce, in flowing, new and unforeseen elements. [68]

Durational succession, then – the movement from past, to present, to future – is a key element in quantum mechanics, as well as in Bergson: in both cases, there is an irreducible novelty that runs counter to any predetermined or predictable schema, such as that of classical mechanics, where all effects have Laplacian causes.[69] Here, indeed, Bergson's argument with Einstein finds common cause with those of quantum theory. There *is* a time for which philosophy has understandings that the Special Theory of Relativity does not, and it is something far more profound than merely 'psychological time'. The flow of time produces novelty; and for novelty to exist, time requires consciousness, in the form of memory.

On consciousness, durational succession, and epiphenomenalism

Now, Bergson speaks of consciousness in many different ways, at different times, and never offers – declines to offer, in fact – a definition.[70] But there are specific *kinds* of consciousness that he does speak about. Life is where Bergson mostly locates consciousness. Amongst animals, it is clear for Bergson that it is mobility that brings consciousness, as we saw in Chapter 2: 'the humblest organism is conscious in proportion to its power to move *freely*.'[71] But such free movement is, inevitably, almost entirely devoted to the necessities associated with maintaining the biological machine that is the animal body, by which that consciousness is made possible. Only in humanity does the maintenance of the machine of the body become automated through tool manufacture and use, freeing consciousness to focus on other things.

For Bergson, in the latter half of *Creative Evolution,* however, consciousness is also the starting point of life, and in the vegetable it is asleep, in the animal, awake:

> It is as if a broad current of consciousness had penetrated matter, loaded, as all consciousness is, with an enormous multiplicity of interwoven potentialities. It has carried matter along to organisation, but its movement has been at once infinitely retarded and infinitely divided. On the one hand, indeed consciousness has had to fall asleep, like the chrysalis in the envelope in which it is preparing for itself wings; and, on the other hand, the manifold tendencies it contained have been distributed among divergent series of organisms which, moreover, express these tendencies outwardly in movements rather than internally in representations. In the course of this evolution, while some beings have fallen more and more sleep, others have more and more completely awakened, and the torpor of some has served the activity of others.[72]

'Life,' he concludes, 'that is to say consciousness launched into matter,'[73] does not exist only in the animal, or, indeed, asleep, in the vegetables that serve the activity of animals. If life is the product of consciousness launched into matter, then it must exist alongside matter too, albeit as its corollary; matter and consciousness merely side-by-side in the inert, consciousness 'launched into matter' in the living. Indeed, consciousness, as we saw in Chapter 2, is referred to frequently simply as memory: 'Memory' Bergson says, 'may lack amplitude; it may embrace but a feeble part of the past; it may retain only what is just happening; but memory is there, or there is no consciousness.'[74] Thus, the consciousness not launched into, but merely alongside matter may be interpreted as memory, albeit in minimal form: the memory of matter.

In this understanding, then, for Bergson, consciousness is even more than what we find, in varying degrees and at various levels of complexity, in life; it is also something which is central to the *durée réelle* – to the duration of the universe – and to be found in the very succession of past, present and future. Indeed, he asserts, we find 'in duration the very stuff of reality.'[75] We may conclude then that all of existence is conscious insomuch as it *endures*. Let us unpack this further. If we speak of the material universe – of all of existence – being conscious, we do so meaning that such a universal consciousness is the primary originator of all others – their 'principal'. This is quite different from suggesting that the universe has some kind of individual consciousness itself, such as that of a God. As Bergson says, 'We do not mean the narrowed consciousness that functions in each of us'[76] – be that of an animal or a human being. 'Our own consciousness,' as Bergson tells us, 'is the consciousness of a certain living being, placed in a certain point of space; and though it does indeed move in the same direction as its principal, it is continually drawn the opposite way, obliged, though it goes forward, to look behind. This retrospective vision is, as we have shown, the natural function of the intellect, and consequently of distinct consciousness.'[77] The 'principal,' to which Bergson refers here, is the universal consciousness of which the individual consciousness is but a distinct part: facing the opposite way, seeing what is past. 'In order that our consciousness shall coincide with something of its principal, it must detach itself from the *already-made* and attach itself to the *being-made*.'[78]

So, how might we characterise this material consciousness – this consciousness of the universe, this 'background, which, for want of a better name, we may call consciousness in general, and which must be coextensive with universal life.'[79] Clearly it is in this fractional material memory that we will find it, and its implications for our previous discussion of quantum probabilities are profound. For Bergson, as we have seen, the universe is in flux, perturbations and modifications continually upon the move, and the mobility itself, the durational succession, is where this 'consciousness in general' unfolds.

Using Faraday's speculation concerning electric conduction (though we might equally use the work of Niels Bohr) Bergson addresses the notion of materiality in terms, describing the concrete as made from vibration or energy. Materiality is in this sense a view of the mind that is getting ready to act, set in a 'space' set up by the mind. In quantum terms, we might describe this flux as sub-atomic wavefunctions. At this level, where probabilities are all we can determine, as we have seen in Louis de Broglie's remarks, there is sufficient indetermination for the possibility of a mind/matter connection: consciousness, in the form of memory, may cross the Cartesian divide and have causal effect upon matter. Now, it transpires that 'Neils Bohr, Eddington and Pascual Jordan were the first physicists to point this out,'[80] Čapek tells us. At bottom, then, if at this level consciousness comes in the form of memory, then it is here that Bergson's universe becomes panpsychistic, and his philosophy of time something far larger and deeper than both the time of Einstein's physics, and of psychological time.

Consciousness becomes a property, not just of humans or animals, or asleep in the vegetable kingdom, but a property of all matter, albeit in different degrees. Consciousness, understood as memory, we can in fact regard as presupposed by the progress of duration, by the movement from past to present to future. The nature of such a succession requires that there be a relationship between present and past that links as well as distinguishes the two – a relationship that makes of the present something 'new', at the same time as being a continuation of the past. Because the past – by definition – no longer exists, once the present has arrived, such a thing, in this succession, as 'newness' cannot exist unless it contains some corollary of 'memory' by which to differentiate. Durational succession thus becomes dynamic, asymmetrical, and internal. As Bjelland puts it:

1. *Durational succession is a Dynamic Relation*. Durational succession, as a 'becoming of continuity,' is a dynamic relation linking past and present…
2. *Durational Succession is an Asymetrical Relation*. The succession of one physical event by the next involves the emergence of a novel present which, no matter how conformally continuous with its causal past, is not identical with that past…The novelty of the present is impossible apart from the persistence of the past as its qualitatively contrasting ground.
3. *Durational Succession is an Internal Relation*. The sheer advance of present over past involves the prescription of some *minimal* novel agency to the present event [memory]…Durational succession is intelligible only in terms of the qualitative differentiation of present from past, which differentiation itself depends on the mnemonic survival of the past in the present.[81]

The present thus arrived at, pregnant with the memory of the past of which it is simultaneously a continuation and a break from, the future – if it is indeed to be novel in the same manner as the present has been with regard to the past – must in fact be a number of possibilities, one of which will become the new present in a future not yet chosen. As Čapek puts it:

> In the temporal continuity of real process of causation…the causal or 'mnemic' influence of the past is not denied; but the present, though co-determined by the past, nevertheless contains an element of irreducible novelty…In such a growing world every present event is undoubtedly caused, though not necessitated by its own past. For as long as it is not yet present, its specific character remains uncertain…It is only its presentness which creates its specificity, i.e., brings an end to its uncertainty, by eliminating all other possible features incompatible with it. Thus every present event is by its own nature an *act of selection* ending the hesitation of reality between various possibilities…As far as the *future* is concerned, it is the future and not a disguised and hidden present as in the necessitarian scheme: it *will* arise, it *is not yet*. But because it will not emerge *ex nihilo*, but from a particular present state, its general *direction* is outlined and thus possesses some general predictable features– the more predictable the larger the statistical complexes of the elementary events that are considered. Hence arises the possibility of practically accurate prediction of microscopic events.[82]

Laplace's demon, in other words, must finally be banished. Laplace's view of science, the philosophical backdrop to all classical, 'objective' science, has always been that 'a description is objective to the extent to which the observer is excluded.'[83] An 'objective' scientific description, therefore, can only be 'made from a point lying *de jure* outside the world, that is, from the divine viewpoint to which the human soul, created as it was in God's image, had access at the beginning.'[84] It is, in effect, a science that relies upon the Cartesian divide. Laplace's is an 'objective' world in which consciousness has no place, and no causal connection to the real.

But, in this quantum space – where the possibilities of the future have not yet been reduced to the one that *will* come, this space of *indetermination* – the mind may indeed impact upon matter, and consciousness become an integral part of the physical unfolding of the universe. Memory, in the unfolding of duration, in the flow of wavefunctions, puts consciousness at the heart of existence, not as a physicality, but as physicality's durationality. As Bergson puts it, we find 'in duration the very stuff of reality'.[85] Life, moreover, gathers together great amounts of energy (solar energy photosynthesised) to enable organisms to grasp, as the flow unfolds, crucial moments of indetermination, and through *choice* pick amongst the possibilities of the future that which suits them best. As we saw in Chapter 3, as Milič Čapek describes it, organisms may be thought of as *amplifiers of quantum mechanical indetermination*. Nor was this Čapek's idea. As he tells us, the idea that organisms could be regarded as amplifiers of microphysical indetermination was suggested by Niels Bohr in 1931.[86] The idea was developed by Pascual Jordan in the 1930s, and again by Bohr in 1957.[87] Walter Elsasser, in the late 1940s, 'formulated a similar theory in the light of new neurological data and related it explicitly to Bergson's views.'[88] Čapek has his criticisms of both Jordan and Elsasser's approaches, but it is that they were still too mired in the Laplacian universe, and had not yet taken sufficient a leap into statistical probability and indetermination.

What is at stake here, of course, when considering the mind's effect upon matter, is the scientific belief in epiphenomenalism. As we saw in Chapter 2, epiphenomenalism – still the default position of scientific realism and most neuroscience to this day – suggests that mind and matter are completely separate: that mind is immaterial and has no causal link with matter. Consciousness is thus described as an epiphenomenon of the brain, a non-functional supplement that is caused by brain events but has no causal effect upon brain events. It is a curious position: a paradoxical one, in fact. The scientist who suggests it is saying, in effect, 'I am aware that no awareness exists.'[89] It is a position born of the Cartesian existential divide that Bergson had to redress in his philosophy in order to bring an understanding of time back into play. The fundamental problem of Cartesian and all other such dualisms is that, if the mind is placed beyond the physical, beyond space, as Descartes did, then 'any interaction between the mental and physical [is] excluded by the laws of classical physics, more specifically, by the laws of conservation of energy and momentum.'[90] How could anything immaterial, after all, be a cause – in a Newtonian universe – of any material effect? The equations of classical dynamics thereby have to invent, from thin air, energy or momentum, in the translation between the two: something quite impossible. Worse, the material cannot actually have any effect on the immaterial – no awareness can actually exist – since a physical impact on mind would require the disappearance into immateriality of the energy/momentum of the physical cause. Because of this illogical – yet foundational – distinction between mind and matter at the heart of the Cartesian mechanistic foundation of classical physics, we are faced with the absurdity of a becomingless matter, stuck forever in a static spatial universe in which only mind – Einstein's 'psychological time' – has any concept or experience of durational succession. Mind and matter are so completely distinct in this divide that there is 'no conceptual model of their correlation and interaction'[91] – entirely contrary to common sense.

The Dutch philosopher Spinoza (1632–1677) tried to solve this Cartesian impasse in his philosophical and theological treatises and his posthumously published *Ethics*. He opposed Descartes's mind–body dualism by suggesting, in effect, a third state, of which mind (Thought) and matter (Extension) were the two correlates – two attributes of God, manifest in a united, monist, cosmos. Spinoza's main problem with Cartesian dualism, of course, was that if mind and body are truly distinct, then it is not clear how they can coordinate in any manner. In this third state then, there were, according to Spinoza, direct parallels between everything that is thought and everything that is extension: a mental and a physical half to everything.

Spinoza's ideas were welcomed and hailed as a philosophical grounding for modernity. But this compromise was shrunk in the 19th century to apply essentially only to human awareness, rendering the rest of matter devoid of any psychic correlate, and the psychic aspect deemed to accompany only 'some physiological processes in the central nervous systems of higher vertebrates'.[92] The rest of the physical universe was left devoid of any psychic correlates. In this way the original universal parallelism of Spinoza was modified in the sense of epiphenomenalism; in the words of Thomas Huxley who coined this term, 'The consciousness of higher living beings merely accompanies certain neural processes without influencing them.'[93] Thomas was of course grandfather of Julian Huxley, whose book on the evolutionary modern synthesis became gospel in 1942, with all the von Neumann-inspired mathematicisation of ecology unfolding around him. It was, indeed, Julian Huxley who in 1926 had reserved his harshest criticisms for Bergson: mistaking the *élan vital* for some substantival vitalism, he suggested that it was 'as useful in explaining evolution as the "Elan Locomotif" is useful in explaining the movement of the train.'[94] It is a sad irony of history that the fruit of Bergson's internationalism, UNESCO, was to be led, as its first Director in 1946, by Julian Huxley.

Yet, if consciousness can have no impact upon the physical world, one might equally ask of the Huxleys how anything such as an epiphenomenal consciousness could ever have evolved? Natural selection surely only preserves features that are of use? Indeed, what with the obvious causal efficacy of pain and pleasure, and so on, one wonders how something as nonsensical as epiphenomenalism could ever have been accepted and adopted. As Bergson put it:

> Certainly, the psychophysiologist who affirms the exact equivalents of the cerebral and the psychical state, who imagines the possibility, for some super human intellect, of reading in the brain what is going on in consciousness, believes himself very far from the metaphysicians of the 17th century, and very near to experience. Yet experience pure and simple tells us nothing of the kind. It shows us the interdependence of the mental and the physical, the necessity of a certain cerebral substratum for the psychical state – nothing more. From the fact that two things are mutually dependent, it does not follow that they are equivalent.[95]

Granting, then, that epiphenomenalism is fraught with internal contradictions – that, on the contrary (and in line with common sense), consciousness is both impacted by, and impacts upon the material universe, it is then but a short step further to consider the fractional 'memory' of reality being that which enables it to *endure*. Then the durational succession of the universe – replete with its connection to a wider consciousness that finds ever greater expression of *choice,* or indetermination, the more concentrated it becomes – leads us ultimately up to our own, human consciousness, and the understanding that that consciousness is like a window through which universal consciousness may look back upon itself, upon the world. The irreversibility of time in physical processes, in other words, must reincorporate consciousness back into the universe, too.

In sum, reversible time – the non-temporality of Newtonian dynamics that gave laws to the material world on one side of the Cartesian divide, foundation of the balanced, reductionist, mechanistic view of the world so prevalent in the 19th century, and retaining a powerful hold over the popular imagination to this day – was, even as early as 1811, already being challenged by the study of heat. By the middle of the century the concept of entropy had already split the physics community in two: classical dynamics and thermodynamics. By the early 20th century – with the discoveries of relativity, astrophysics and quantum mechanics – the world of classical dynamics had been shattered: universality replaced with universal constants that warp space and render any simple picture of the sub-atomic meaningless; and the ideal of a static universe, built on simple foundations, rendered historical, evolving, imbued throughout with irreversible processes. Most significantly, both with Bergson and quantum indetermination, the Cartesian mind–body dualism that had set up the mechanistic universe in the first place, and the shrunken post-Spinozan epiphenomenalism that placed an inert consciousness mutely offstage, with no causal link to the brain, were finally being challenged: consciousness had re-entered the universe – no longer shut out as an immateriality forever, so distinct from materiality that it could have no causal impact upon it.

Duration, life and consciousness, indeed – surrounded by perturbations and flux rather than objective fixity – become for Bergson, as we saw in Chapter 2, the *real* foundation of the universe. Life runs in the opposite direction to entropy, gathering order and energy as it unfolds. As Schrödinger argued in his 1944 book, *What is Life?*[96] plants absorb sunlight, using it to build sugars, and then eject infrared light – a much less concentrated form of energy than sunlight. In this way, the overall entropy of the universe is increased by photosynthesis; but plants thus hold back decay by maintaining – through this energy conversion – their orderly internal structure. Animal life, consuming the products of this process, similarly thereby increase the overall entropy of the universe by maintaining their internal order. Above all, however, this process by which life counters entropy is governed by *time*. For, although with our scientific view we may ignore the duration of matter when studying it as so many objects laid out in geometrical space, in truth it is the durational succession, the action of life, and of consciousness – ordering the world in the opposite direction to entropy – which grants matter its opportunity to *endure*: 'weighted with geometry, matter, the reality which descends, endures only by its connection with that which ascends. But life and consciousness are this very ascension. When once we have grasped them in their essence by adopting their movement, we understand how the rest of reality is derived from them.'[97] The universe – which in the view of science could take but one second to unfold, without making any difference – is thus, by the action of consciousness, transformed into a panpsychistic one: conscious in every aspect and everywhere, 'matter' the particulate appearance of consciousness when viewed by consciousness as it is embodied in material organisms that amplify the indetermination within durational succession. A *durée complexe* indeed. Where consciousness is most concentrated, in the higher vertebrates, the qualities of choice and free will are at their most powerful.

On complexity

Consciousness, indeed, returned in scientific circles in the 1960s, through the reimagining of the automatons of cybernetics as being unintelligible without the observer. The ideas of second-wave cybernetics, moreover, giving greater credence to Bertalanffy's notions of 'open' systems, led, as the second half of the 20th century unfolded, to the creation of complexity theory. It will be no surprise, following the genealogy of systems thinking in the last chapter, that the rise of complexity theory is itself a complex story. This volume is not the place for the full story; it is, in some senses, still too early to see clearly enough to paint an accurate picture. As stated before, this volume confines itself to the complex adaptive systems and related concepts in the evolutionary biology of Kaufmann and Goodwin, among others. However, what we have learnt from our discussion of time in the previous section, and the involvement of consciousness, are threads that thus far theorists like Kaufmann have to yet to take fully on board. My task, then, in this section, is, as I point out the confluences between Kaufmann's complexity and Bergson's thought, to show also where Bergson's ideas point the way forward for ecological complexity theorists, in the development of ecological complexity science from now onwards: how his *durée* becomes *complexe*.

On second-wave cybernetics

As we saw in the last chapter, early systems theory was focused exclusively on closed systems, and on the attempt to reduce life to the level of such closed systems. Equally, however, there was other work ongoing amongst systems theorists – and changes of heart amongst some of the proponents of such reductionist approaches – that sought, from the later 1960s onward, to open up systems theory towards new understandings. The classic cybernetic feedback mechanism, in which a sensor/switch controls a heating system, shifts subtly in the late 1960s into a *circular* system, where a sensor/switch triggers a heater and the heater triggers the sensor, which triggers the switch, which triggers the heater, and so on. Seeing the heating system as a true circle, in this new view, changes it from being viewed simply as a system with a control mechanism. The circularity was key, as it vitiates the whole project of reductionism: A becomes analysable by B, which is analysable by C, which is analysable by A. There is no end point to reduction in a circle and a new principle, less simple than Ockham's, must be adopted.

There were a number of early voices in this second wave of cybernetics. To pick out just four, there was Austrian-born Heinz von Foerster,[98] working in the US – the youngest of the core group at the Macy Conferences, and arguably the inventor of second-wave cybernetics with his work on population dynamics. His famous 'Doomsday Equation' suggested – almost tongue-in-cheek – the existence of faster than exponential population rise, due to feedback mechanisms, which could bring humanity to infinite human population by the year 2026.[99]

There was Chilean biologist Humberto Maturana,[100] whose cybernetic biology brought us the term autopoiesis, to describe the nature of reflexive feedback mechanisms in living systems: the idea that the different elements of a system can interact in such a way as to produce and reproduce the elements of the system. In other words, through its elements the system reproduces itself. This idea has proven particularly influential, and been applied (not particularly successfully) by many to social systems too; it was perhaps best imported as a transdisciplinary concept into sociology by the noted German social systems theorist Niklas Luhmann,[101] and has also been used effectively in Bob Jessop's critique of capitalism.[102] Autopoiesis, nonetheless, as a cybernetic concept, conceives closed systems, albeit self-reproducing, in a rather holistic hierarchy of systems and sub-systems akin to Simon's early 1960s classic hierarchical complexity architecture[103] that mirrors the hierarchical management structure of his time.[104] The dissipative structures of Prigogine's and Kaufmann's complexity are, by contrast, open systems – multiple networks of intersecting, interpenetrating and colliding flows.[105]

Another early voice in second-wave cybernetics was Gordon Pask,[106] whose profound and varied work included a cybernetic approach to education, conversation, and the construction of knowledge. Perhaps the earliest voice of all, there was Stafford Beer,[107] whose application of the ideas of cybernetics to management, in the UK, began to lead cybernetics into new territory involving social systems – imagining the firm as an organism.

These scholars were all, ultimately, in the business of extending the application of cybernetic principles toward understanding the role of the observer: so-called 'second-order' or second-wave cybernetics. Whereas first-order cybernetics had dealt exclusively with controlled systems, (in which the observer is not included and does the controlling), second-order cybernetics began to deal with *autonomous* systems – systems where the circularity was understood as intrinsic, and in which the controlling observer was a part of the system as much as what they observed.

This shift brought about some early anthropological behaviourism studies – for example, in the work of Margaret Mead, arguably a fifth key early voice in second-wave cybernetics. It was, in fact, her attempt to apply cybernetic principles to social systems that called attention to the role of the observer, who, while attempting to study and understand a social system, is not able to separate her/himself from the system or prevent her/himself from having an effect upon it. This circularity of cybernetic systems, incorporating the observer of those systems, introduced whole new notions of the *autonomy* of systems. In second-wave cybernetics, stability – understood as continuing-to-be – was regarded as a quality that comes from within the system and its ability to sustain itself, not from comparison to an external reference. This internal stability translated into self-reference, and brought with it autonomy and identity. The possibility of such autonomy in systems proved key to the development of the modern concept of emergence.

On dissipative structures, and emergence

In short, *emergence,* today, describes the order which can arise in an open system, without any possibility of predicting it from initial conditions, due to the complexity of such open systems at far-from-equilibrium conditions, whose 'attractor' states turn out to be spontaneous order.

Let us tease out the concepts here. We are dealing, first, with *open* systems, rather than isolated or closed systems. This is important, because in large measure mechanical and reductionist science has – almost by definition – had to concentrate almost exclusively, from the time of Boyle's vacuum at the onset of the scientific method[108] – with closed systems: it is in the very parameters of laboratory science itself, to do so. Yet, as has become increasingly apparent during the last several decades, heralded by Bertalanffy's work, certainly all *living* systems are open systems: not just integrated into their environments, but 'dissipative structures', through which matter and energy pass, linking not just their substance but their function and their structure to the environment in which they are situated.

Dissipative structures, again, were first described, and termed as such, by Prigogine and Stengers. But the concept arises, of course, from thermodynamics, and chemistry, and no less than Alan Turing was perhaps the first to take an interest in the spatial patterns chemical reactions could produce.[109] Prigogine and Stengers take as their starting point the Bénard cell. Henri Claude Bénard (1874–1939) was the first to accurately describe how different temperatures in fluids between the bottom and the top of a container created a convection effect. 'The convection motion produced,' in this instance, 'actually consists of the complex spatial organisation of the system. Millions of molecules move coherently, forming hexagonal convection cells of a characteristic size.'[110] The most important characteristic of these cells, however, is the relationship between, on the one hand, the structure and order of the cells in this convection process, and, on the other, the dissipation or waste in the heat transfer. To classical thermodynamics in the vein of Carnot et al, all heat transfer is considered a source of waste. Equilibrium structures such as crystals are seen as the end product of the thermodynamic system, and the heat transfer simply a waste producer. But, for Prigogine, in the Bénard cell this process is very different. 'In the Bénard cell it becomes a source of order. The interaction of a system with the outside world, its embedding in nonequilibrium conditions, may become in this way the starting point for the formation of new dynamic states of matter – dissipative structures.'[111] These dissipative structures, moreover, in the Bénard cell, *emerge* from simple thermodynamic processes.

For Prigogine these dissipative structures are nothing less than a 'form of supramolecular organisation.' Bénard cells, as dissipative structures, are directly related to the external environmental conditions – specifically the *nonequilibrium* conditions – in which they are not just situated but by which they are produced. 'The parameters describing them are macroscopic.'[112]

Perhaps an even more straightforward image by which to grasp the nature of emerging dissipative structures is to picture, for a moment, a tap, from which running water pours into a bath. As it flows down through the plughole it forms – spontaneously – a whirlpool, or vortex: this is a dissipative structure. The vortex exists only in the nonequilibrium condition of the flow of water, taking the matter of the water and the energy of its flow in from the tap, and passing it on down the plughole. At the site of its structure, however, the order and organisation of the water molecules makes the spiral of the vortex. This ordering of the water molecules cannot be derived or imputed from the water molecules that make up the whirlpool, nor the forces of attraction or repulsion between those molecules. The order comes from the external environmental conditions – the flow of the water from tap to plughole. In fact the composition of the liquid flowing from the tap is irrelevant. It could be molten lead, mercury, wine, or liquid nitrogen. The same whirlpool would result. (The specific gravity and viscosity of the liquid have an effect on the pitch of the spiral and its rate of flow – the only aspects of the whirlpool affected by the composition of the liquid.[113])

So we are talking about, not just *open* systems but ones where the constituent molecules and their forces can tell us very little about the order that will arise from them. Importantly, too, these unpredictable open systems exist in conditions *far from equilibrium*: not only is the system not at rest – as with a crystal in classical thermodynamics – on the contrary, it has a good deal of both matter and energy passing constantly through it, as with the flow from tap to plughole. The order of the dissipative structure, moreover, *emerges* as a part of this flow, conditioned by the macroscopic parameters, and not by its constituent parts.

On the notion of attractors

Crucially, it transpires, there is an extraordinary opposition in these states with respect to the notion of 'attraction.' Nature, it transpires, according to Planck, 'seems to "favour" certain states. The irreversible increase in entropy…describes a system's approach to a state which "attracts" it, which the system prefers and from which it will not move of its own "free will."'[114] The production of entropy, in other words, acts as an 'attractor' state favoured by nature, and draws all nonequilibrium closed systems towards being closed systems in equilibrium. This language of 'attraction' and of 'attractor states' becomes extremely important in complex systems.

Evolution toward an 'attractor' state is something that is different to any and all other types of change. Equilibrium, for example, is a state that is an 'attractor' of nonequilibrium states – at least, in isolated systems. As we shall see, in open systems this turns out to be very different. This is a world away from classical dynamics. As Prigogine relates: 'In dynamics, a system changes according to a trajectory that is given once and for all, whose starting point is never forgotten (since initial conditions determine the trajectory for all time). However, in an isolated system *all* nonequilibrium situations produce evolution toward the *same* kind of equilibrium state. By the time equilibrium has been reached, the system has *forgotten* its initial conditions – that is, the way it had been prepared.'[115] Attractors, in the terminology of dynamical systems, are like lakes, into which the rivers of the uplands drain. Such a lake, or the area around an attractor, is therefore called a 'basin of attraction'.[116]

On the universal scale, entropy is drawing all things in the universe towards an ultimate state of rest – the 'death' of the universe. But in nonequilibrium *open* systems, by contrast, the 'attractor' state appears to be the spontaneous order of these dissipative structures. The order of the equilibrium closed system is rest, completed entropy, death. The spontaneous order of the open system is the dissipative structure: order, apparently – as suggested by the title of Prigogine and Stengers' book – from chaos, and not the other way around.

Emergence, then, is the term used to describe how the ordered structures which, beyond the possibility of predicting them from their constituent parts, tend (by attraction) to *emerge* spontaneously in open systems – in the opposite direction from the general tendency of entropy. Just like the universal constants of the speed of light and the derivation of a particle's wavelength, *emergence* breaks the clockwork predictability of the Newtonian world. The traditional analytical approach – breaking things down to their constituent parts – tells us only incidental things about *emergent* structures: like the pitch of the spiral in the bath. Likewise, just as Hubble's expanding universe adds a history to Einstein's space-time continuum, the concept of *emergence* brings the arrow of time into the organisation of matter in radically unpredictable ways. Emergence presupposes a durational succession in which there is an irreducible novelty, an unpredictable set of possibilities the singling out of one of which only the present will reveal, as it succeeds the past. Beyond, even, the work of physics, in the end, which can, after all, tell us only about the physical properties and forces involved in the world around us, *emergence* starts to tell us something about life*: the organism is an emergent system.*

Clearly Bergson's ideas in *Creative Evolution* are here very much in tune with these concepts of emergence and attraction – taking us, indeed, into what I here am attempting to delineate by the term, *durée complexe*. The *élan vital* can be closely aligned with the concept of emergence, and Bergson's notion of evolutionary tendency with that of attraction. 'No doubt,' Bergson claims, 'every living cell expends energy without ceasing, in order to maintain its equilibrium,'[117] and 'every animal cell expends a good deal – often the whole – of the energy at its disposal in keeping itself alive.'[118] The animal cell, in other words, is a dissipative structure, through which flows solar energy, captured and stored by the phytoplasmic activity of the vegetable world as food. Moreover, as evolution unfolds, imperfect and often incoherent, it nonetheless clusters around particular, strong lines of development – 'tendencies', as Bergson calls them; or 'attractors,' in Kauffman's terms. 'We must recognise that all is not coherent in nature. By so doing, we shall be led to ascertain the centres around which the incoherence crystallises,'[119] Bergson tells us.

Bergson describes the action of the *élan vital,* as we saw in Chapter 2, as a tendency that creates a 'sheaf' of divergence, bifurcating along a host of different and varied lines. Thus there have been two or three principal 'highways' of development, between which 'run a crowd of minor paths in which…deviations, arrests, and set-backs, are multiplied.'[120] These *tendencies* we can understand in light of the mechanism of attraction. As evolutionary novelty emerges, so certain states are favoured, and, besides the surviving 'dead ends,' there run major 'highways' of the most prevalent attraction.

Let us unpack these ideas further.

On organisms and nonequilibrium

Biology, like systems theory, had for much of the 20th century developed under the all pervading influence of John von Neumann and the physicist's paradigm described in the last chapter, and was following a very analytical and reductive route. In the early 1950s, significantly, a whole new branch of biology seemed to open up, with the famous discovery of the DNA double helix by Watson and Crick.[121] This 'genocentric' biology, focusing life around the organic chemicals of genetics, held much promise – and the attention of most biologists and their funding bodies – well into the 1990s, culminating in the sooner than expected publication of the entire human genome.[122] The apotheosis of the genocentric view is, of course, famously found in the work of Richard Dawkins.[123]

The mechanistic, reductionist approach to biology epitomised by the genocentric view is of course to suggest that all life is predictable from the initial states discernible in the genes: genetics promised, for the genocentric biologist, a view akin to Laplace's demon, the atomic key to life. Of course, it quickly proved a red herring, in this respect. Goodwin's critique of Dawkins' genocentric biology is particularly scathing, equating Dawkins' underlying mythos with the Christian mythos of the fall and redemption of humanity.[124] For Goodwin, Darwin's evolutionism not only removed God but also the human spirit. Dawkins brought the human spirit back: 'The body of the organism,' in this view, 'which to the naïve observer seems to be the main part, is really just packaging for the hereditary essence,' as Goodwin relates. This 'hereditary essence' of Dawkins' would, to any casual observer, sound more like an immortal soul or some kind of divine vitalism, were it not for Dawkins' own vociferous attacks on anything remotely religious.[125] Perhaps he doth protest too much? As Goodwin asserts (never mind Kuhn or Foucault), 'Science, after all, is not a culture-free activity'.[126]

But in the years since the publication of the entire human genome, it has become increasingly clear that the genocentric view has a good number of complications, quite apart from its reductionist approach. As pointed out in Chapter 2, it transpires that the expression of genes is far more important than at first realised, that environmental factors play a far greater role in whether particular genetic traits are expressed or not, and that the possibility of reducing pretty much anything about our bodies, behaviours, and pathologies to genes alone was a false hope (of the reductionists): it's all a lot more *complex* than that.[127]

It was the work of Daniel Botkin, and his famous book, *Discordant Harmonies,* that broke the mould in the field of environmental biology, with its very accessible depiction of the sheer *lack* of equilibrium and stability in the natural world. As we have seen, throughout the 20th century, the predominant theories in ecology 'either presumed, or had as a necessary consequence a very strict concept of a highly structured, ordered, and regulated, steady-state ecological system.'[128] Botkin makes it very clear how this view is wrong at local and regional levels, at the levels both of populations and of ecosystems. 'Change,' he stresses, 'now appears to be intrinsic and natural at many scales of time and space in the biosphere.'[129]

One of the striking aspects of Botkin's work is in his assertion that the individualism of 19th century approaches to evolution is misleading. As he says:

> Individuals are alive, but an individual cannot sustain life. Life is sustained only by a group of organisms of many species – not simply a horde or mob, but a certain kind of system composed of many individuals of different species – and their environment, making together a network of living and non-living parts that can maintain the flow of energy and the cycling of chemical elements that, in turn, support life.[130]

One might say, in fact, that species, ecosystems, whole biomes – the entire biosphere – may be characterised as dissipative structures, through which the flow of energy and the cycling of chemical elements that support life take place. That a study of the individual alone, or the processes associated only with individuals, could tell us all there is to understand about such vast interpenetrating systems, is no longer tenable. Their behaviour, like that of the flow of water from tap to plughole, actually has little to do with that of the individual components – the molecules of water; it is more a macroscopic property of their collectivity, of the energy and unfolding of their durational flow from past to present to future.

This nonequilibrium ecology soon gathered a huge following, and great debates with the continued believers in equilibrium raged for a decade or more. There is perhaps today something of a rapprochement, suggesting various kinds of a mixture of the two may be at play, in different contexts.[131] While genocentric biology has nonetheless continued apace, and promises much of value, and molecular biology in general continues to be of great interest and produces new insights all the time, nonetheless the attempts of past ecologists – as we saw in the last chapter – to treat life broadly as a closed system, tending toward some metaphorical equilibrium in the vein of Darwin's entangled bank, and the idea that the reductionist approach of genocentric or molecular biology could be the whole story, somehow just adding up to the grand total, has met fierce resistance in the last two decades.

Organisms were, for Darwin, the principle focus of attention, but in 20th century genocentric and molecular biology, had become all but completely effaced. In the late 1980s and early 1990s organisms started to be looked at again, in environmental biology, and to make a comeback. As Goodwin succinctly put it in 1994, 'Some of the basic assumptions that underlie the conceptual structure of the present view of biology are inconsistent with the evidence.'[132] Goodwin lists them:

i. *The reductionist approach is insufficient:* 'The morphology of organisms cannot be determined by the action of their genes.'[133] Carbon (like many other elements) can generate crystals. Many kinds of crystals. Which crystal is formed is determined not by its constituent parts, but by the environmental conditions. The idea that the genetic instructions are sufficient for the formation of the heart, lungs and other major organs is equally untenable. 'Knowing the molecular composition of something is not, in general, sufficient to determine its form .... We also need to know the principles of organisation that are involved.'[134]
ii. *Genes are not the whole story:* DNA is not self-replicating. It is the cell that reproduces. In laboratory conditions the chemical process of DNA replication tends rapidly toward simplification. In the real world in cellular and organismic contexts greater and greater complexity is the norm: 'the whole system evolves as a reproducing unit.'[135]
iii. *Reproduction is not a separable function:* 'The capacity to reproduce is a property of the whole organism, not a special replicating part that is distinct from the rest of the reproducing body.'[136]

The implications of these challenges within biology means, for Goodwin, that the organism returns to being considered a fundamental unit of life, and that evolution needs to be looked at again. The genocentric view, in Goodwin's eyes, is insufficient. But, as we saw with Gould, neither are organisms sufficient in themselves as units of selection, and the species, too, must be considered. Each of these – genes, organisms and species –

must also be decoupled, allowing differing systemic behaviours at each level, in Gould's hierarchical model.

On nonequilibrium thermodynamics

The gradual approach to an understanding of autonomy in systems theory, via second-order cybernetics, and the shift away from molecular reductionism among environmental biologists, soon began to find common cause.

The crucial breakthrough, as it happens, occurs in biochemistry, in a Soviet petri dish. Used to the homogenous reactions of chemicals in controlled conditions, chemists by and large do not expect to see dynamic patterns in their petri dishes. Yet this is precisely what was discovered, in a laboratory in Moscow, during the height of the Cold War. Boris Belousov, working in Moscow in the 1950s, discovered and studied chemical reactions in a particular mix of chemicals that seemed to create an oscillation between alternate colours in his petri dish. A mixture of potassium bromate ($KBrO_3$), malonic acid ($CH_2(COOH)_2$), and cerium sulfate ($Ce(SO_4)_2$) was prepared in a heated solution of citric acid ($C_6H_8O_7$) and sulphuric acid (H_2SO_4).

The result was an oscillating pattern of alternating colours, observable to the naked eye on the extremely convenient human time scale of dozens of seconds and extending over dimensions of several millimetres. One chemical (cerium IV) was being reduced by one of the acids (malonic) in the mixture to another (cerium III), which was then being oxidised by a third chemical (bromate V) back into its original form (cerium IV). One chemical was yellow, the other colourless. Not only did the colours alternate, they produced beautiful and fascinating patterns in the dish as the movements of the chemicals expanded in waves and the waves of movements interfered with one another.

Belousov couldn't get his findings published, but Anatoly Zhabotinsky rediscovered the phenomenon with other chemicals in 1961.[137] Finally, in 1968 in Prague the results of both men's work were disseminated at a scientific conference. The so-called Belousov-Zhabotinsky or BZ reactions gradually drew more and more attention and eventually became a classic in global biochemistry. Here we find the nascent notions and understandings of circularity in systems from second-order cybernetics describing the behaviour of linked reactions in biochemical systems. The patterns within the dish are created by a self-referential, autonomous chemical system that can and does continue over long periods. The usual trajectory of chemical reactions, from something unstable to something stable, in the classic equilibrium model (even if stability and equilibrium

Figure 5.1 A Belousov–Zhabotinsky reaction
Source: Dr. Arthur Winfree/Science Photo Library

are only achieved through an explosion!), no longer applies in these experiments. The BZ reactions, in fact, are one of the classic examples of nonequilibrium thermodynamics, presenting a self-sustaining autonomous chemical system. The reactions, moreover, once extrapolated into the wider living world, provide a biochemical model of nonequilibrium biological phenomena, opening a window into an understanding of open biological systems – organisms – as autonomous dissipative structures. The patterns observed in the BZ dishes, for example, turn out to be analogous to those observed in cardiac arrhythmias – heart tremors.[138] One pattern in the dish corresponds to the stable pattern of contraction in the muscles of the heart that gives us a steady heartbeat. A second pattern in the dish corresponds to a chaotic twitching in those muscles associated with palpitations.[139]

On autocatalysis and phase transitions

The chemical reactions of the BZ dish can be seen as an example of chemical catalysis, a 'control'-type description of chemical reactions in which one chemical 'catalyses' another. Specifically, transition-metal ions (e.g. the Cerium ions) catalyse the oxidation of various, usually organic, reductants (e.g. malonic acid) by bromic acid in an acidic water solution. But, as we saw above, the same chemical reaction can be described from the other viewpoint – where the cerium IV ions are reduced by the malonic acids in the mixture to cerium III ions, which are then oxidised by the bromate V back into cerium IV ions. The system of catalysing and reducing reactions in the dish that produces the patterns – chemical reactions that are essentially circular in nature – is called *autocatalysis*. A single chemical reaction can be described as autocatalytic, if the product of the reaction is also the catalyst for that reaction. A set of chemical reactions can be described as 'collectively autocatalytic,' if at least some of those reactions produce catalysts for enough of the other reactions, so that the entire set of chemical reactions is self-sustaining, given sufficient input of energy and food molecules. This is known as an autocatalytic set. The ideas of second-order cybernetics enter the biochemistry laboratory.

In fact, none other than Stuart Kauffman, as early as 1971, (building on work in the late 1960s on genetic nets[140]) was making this connection between molecular systems and cybernetic theory in the inaugural issue of the *Journal of Cybernetics*.[141] In this paper – the only biologist in this first issue of the new journal – Kauffman proposed the self-organised emergence of collectively autocatalytic sets of peptides, for the origin of molecular reproduction. BZ style patterns and such autocatalytic systems occur, in other words, not just in dishes with a mixture of organic chemicals, but amongst single-celled organisms – for example the amoebas in cellular slime mould.[142]

A very primitive life form, cellular slime mould, has two distinct phases to its life cycle. Whilst food in the form of bacteria is available the amoebas of the slime mould exist as independent, single cells, crawling about on their hunt for and consumption of food. As single-celled organisms, their reproduction consists in growth and division, and during this phase they seem to pay little if any heed to one another. This is in sharp distinction to the second phase of their cycle. Once the food runs out, the amoebas start to signal to one another, releasing a chemical that constitutes communication from cell to cell. The release of the chemical creates a centre to which cells receiving the signal start to move – at the same time also releasing a burst of the chemical themselves. In laboratory conditions, in a petri dish, these movements quickly begin to resemble the spatial patterns observable in the BZ reaction.[143] This aggregation, moreover, then morphs gradually into a multicellular organism: 'the initially simple aggregate of cells becomes progressively more complex in form, and the cells in different positions differentiate into specific cell types. The final structure consists of a base, a stalk that rises up from the base, and on top a "fruiting body" made up of a spherical mass of spores that can survive the absence of food and water. When conditions recur that allow growth, the spores are released from the fruiting body and germinate – each one producing an amoeba that feeds, grows, and divides – and the life cycle starts again.'[144]

What is taking place in this shift from a mere aggregation of independent amoebas to a purposeful multicellular organism? Clearly there are organic chemical reactions underway that generate transformations, but also there seems to be a fundamental transition from multiplicity to unity – from chaos to order.

For a less biological, more conceptual explanation of this process, Kauffman has an interesting tale that illustrates this type of what he describes as a 'phase transition,' involving buttons and threads:

> Imagine 10,000 buttons scattered on a hardwood floor. Randomly choose two buttons and connect them with a thread. Now put this pair down and randomly choose two more buttons, pick them up, and connect them with a thread. As you continue to do this, at first you will almost certainly pick up buttons that you have not picked up before. After a while, however, you are more likely to pick at random a pair of buttons and find that you have already chosen one of the pair. So when you tie a thread between the two newly chosen buttons, you will find three buttons tied together. In short, as you continue to choose random pairs of buttons to connect with a thread, after a while the buttons start becoming interconnected into larger clusters.... A phase transition occurs when the ratio of threads to buttons passes 0.5. At that point, a 'giant cluster' suddenly forms... [as] most of the clusters have become cross-connected into one giant structure.[145]

This, of course, is just a simple binary picture, with buttons that are either connected or unconnected by threads. If the order that emerges in such randomly assembled networks of binary variables is so extraordinary, then, indeed, the order that emerges from complex biological systems must be all the more so. The network dynamics of calculable systems of connections – both simple and complex – brings us the notion of the '*phase transition*,' whereby seemingly random interconnectedness suddenly becomes a web of interrelatedness – the kind of interrelatedness that in the above example creates a web of buttons, and in Goodwin's example of cellular slime mould brought about the fruiting body on its stalk.

On attractors in dynamic networks

A further non-biological illustration of Kauffman's also bears repeating, to help us understand how *attractors* can affect these complex systems: the example of a network of light bulbs in an electrical circuit.[146] Such networks turn out to be the source of extraordinary order. In brief, bearing in mind the BZ catalysis described above, or the case of where an amoeba releases a chemical changing the behaviour of the amoebas around it, imagine, in the light bulb illustration, the behaviour of one light bulb turning another light bulb on or off. Now, there are only two possible behaviours – the light bulb going on, or going off. In such a network, all the light bulbs might be on at once, or all off at once, or any combination of different numbers of them on or off in between. In the case of three networked light bulbs A, B and C, where each bulb can be off, '0,' or on, '1', each light bulb can be receiving from its two fellows in the network one of four different signals: 00, 01, 10, and 11. We can then say, as an experiment, that A will only be switched on – become active – if it receives the following signal from its two fellows: 11 (i.e. both its fellows are 'on'). 'In the language of Boolean algebra (named in honor of George Boole, the inventor of the mathematical logic in the nineteeth century), bulb [A] is an AND gate: bulbs [B] *and* [C] must be active before it will light.'[147] Let us now say that bulbs B and C will, in Boolean language, be OR gates – they will become active if they receive any of 01, 10 *or* 11 from the other two bulbs. 'At each tick of the clock, each bulb examines the activities of its two inputs and adopts the state 1 or 0 specified by its Boolean function. The result is a kaleidoscopic blinking as pattern after pattern unfolds.'[148]

Such a three-bulb system can assume eight different states: A1B1C1 (bulbs A, B and C all 'active' or on), A1B1C0 (bulbs A and B active and bulb C inactive), A1B0C1, A0B1C1, A1B0C0, A0B1C0, A0B0C1, and A0B0C0. Beginning in one state, the system will over time flow through a sequence of different states, often ultimately returning to its original state. This flow – from the initial state back to the initial state, or to a final state different from the initial state – is called a ‘trajectory’. In this finite three-bulb closed system some trajectories (depending on the initial state) will simply repeat, ad infinitum, and this recurrent loop of states is called a ‘state cycle’. If, for example, the trajectory begins at A0B0C0, then the ‘state cycle’ is that all the bulbs are off, and stay off: a short cycle indeed, called a cycle length of 1. If the initial state, however, is A0B0C1, then the trajectory will take it to A0B1C0. This state, however, will produce A0B0C1, the initial state, so the trajectory will just be a simple oscillation between these two states. A more complex trajectory would occur if the initial state were any of A1B0C0, A1B1C0 or A1B0C1, because all these states produce A0B1C1, which itself then produces A1B1C1: a terminal state that produces itself, like A0B0C0.

Boolean networks like this can exist in which all the possible states of the state space can be included in a single trajectory. In a network of 1000 light bulbs, however, the number of possible configurations – the ‘state space’ – is 2^{1000}. If this network ‘were on a state cycle passing through every one of this hyperastronomical number of states, and if it took a mere *trillionth of a second* per state transition, we could never in the lifetime of the universe see the system complete its orbit.’[149] So the number of states in a trajectory can be manageably small, or so large as to be meaningless. A small cycle will display order, a large one will be totally unpredictable, chaotic. Autocatalytic chemical networks involving several thousand kinds of molecules, then, needless to say, need *small* state cycles. They have to have *attractors* that pull them into order.

In the light bulb example above, A1B1C1, what I described as a ‘terminal’ state, is actually an *attractor*. The four different states A1B0C0, A1B1C0, A1B0C1, and A0B1C1 all (ultimately) produce A1B1C1. It is a steady state, lying in a ‘basin of attraction’. Such attractors can become sources of order in large dynamical systems, not just making steady states but also drawing trajectories into small regions of their otherwise potentially vast state space. So, in the network of 1000 light bulbs, where the number of possible configurations is 2^{1000}, an attractor might pull together a short trajectory using only a small fraction of the possible states, cycling in a nice, orderly, system. Too small a trajectory and the state cycle reduces to 1 – an ‘order’ that is inert. Too large a trajectory and there is no order at all: the state cycle is so long as to be meaningless, chaotic.

Such systems as molecular autocatalytic sets, of course, not only need to have attractors pulling them into manageably small state cycles, but need also to exhibit Cannon’s *homeostasis* – they must be sufficiently robust to absorb small perturbations. Attractors, for Kauffman, are the source of such homeostasis, draining large basins of possible states down to their orderly few, ensuring that minor fluctuations due to environmental pressures still cycle down quite quickly toward the attractor state. Importantly, the simpler, steady states, such as A0B0C0, are not homeostatically stable. Change one light bulb from off to on and the system shifts from its steady state immediately and heads off down a new trajectory – towards a new basin of attraction. Attractors only work when there are a large number of possible states, and a reasonable cycle to which they might be homeostatically confined. This is true of complexity in general – there needs to be a good deal going on.

For Kauffman, the development of Boolean networks in molecular contexts and the potentials of 'phase transitions' within them is responsible for nothing less than the origin of life itself.[150] Autocatalytic sets of molecules arose spontaneously at a certain level of complexity in the primordial soup – like the buttons and threads random interconnectedness suddenly coalesced into a giant cluster of interrelatedness. Perturbations in the environment then tweaked their parameters to take such sets to the very edge of chaos, where they were both homeostatically ordered enough to avoid descending into chaos if perturbed, yet flexible enough to adapt to ever-changing environments. Thereafter, 'Natural selection finds its role as the molder and shaper of the spontaneous order for free.'[151]

As Bergson said – and we could imagine here the button-and-thread like molecules of the primordial soup – 'Of phenomena in the simplest forms of life it is hard to say whether they are still physical and chemical or whether they are already vital.'[152] As we saw in Chapter 2, it is here in fact that Gould thought Kauffman's work was strongest. But more than this, as Kauffman asserts, 'This theory of life is…born not of mysticism, but of mathematical necessity.'[153] For Kauffman it is only when there is sufficient diversity of molecular types that the phase transition to life can occur, but when that diversity is reached catalytic closure occurs – similar to the giant web of buttons – and life emerges, whole: not piecemeal, bit by bit, but whole, all at once. This, says Kauffman, is why there are no living things smaller than pleuromona (a kind of bacterium);[154] nothing smaller – or less complex – can *live*. They are like the quanta of life. Moreover, in this case, 'life is vastly more probable than we have supposed.'[155] Indeed, as Bergson asserted, and as we saw in his arguments in *Creative Evolution* concerning the complex nature, and recurrence across such a wide range of organisms, of the eye, 'Nature has had no more trouble in making an eye than I have in lifting my hand.'[156] For

Goodwin, there is, indeed, 'an inherent rationality to life that makes it intelligible at a much deeper level than functional utility or historical accident,'[157] and the dynamics of complexity and emergent order are the key to understanding the origin and the nature of life.

On self-organisation

If life has indeed come into being and developed in the way that Kauffman and Goodwin describe – in phase transitions at certain levels of complexity amongst the requisite diversity of molecules, and the various organisms that we see around us in fact display all the signs of this inherent order and structure – then life is *self-organising* in a profound and fundamental way. Indeed, the primary force behind evolution, for Kaufmann, is self-organisation: 'Life and its evolution have always depended on the mutual embrace of spontaneous order and selection's crafting of that order.'[158] The diversity of life feeds on itself, driving itself forward. 'Cells interacting with one another and with the environment create new kinds of molecules that beget yet other kinds of molecules in a rush of creativity.'[159] This rush, which Kauffman calls 'supracritical behavior', derives from the same phase transitions that brought about the origin of life in the first place. The historical, accidental, struggle for survival – depicted by Darwin at the level of the organism; by Dawkins at the level of the genes; by Gould at the level of species: long unchanging and then (in geological time) making sudden evolutionary leaps – are all certainly there, in the picture, as a consequence of the interpenetrating environments and interconnected systems of organisms as they interrelate within and across the biosphere. But this is only a *secondary* picture, something that is *also* going on, a *corrective* and *shaping* process that is an *adjunct* to evolution proper: emergent self-organisation.

Now, using different words and coming at this from a slightly different perspective, Bergson nonetheless – in *Creative Evolution,* as we saw in Chapter 2 – makes almost the same argument when discussing the failings of mechanism.[160] He is at pains to distinguish between the concepts of manufacture and organisation.[161] Manufacture – a very human approach – takes discrete elements and puts them together: 'To manufacture, therefore, is to work from the periphery to the centre, or as the philosophers say, from the many to the one.' Understanding organisms after the image of manufacture, then, we need something like natural selection to gives us an appreciation of how each individual element – to which we have reduced the organism – can have independently arisen. 'Organisation,' however, 'on the contrary, works from the centre to the periphery. It begins in a point that is almost a mathematical point, and spreads around this point by concentric waves which go on enlarging.'[162] Understanding Bergson's organisation as self-organisation, in contrast to reductive manufacture, the concentric waves is an image reminiscent of the catalytic patterns we have been discussing, in the BZ petri dish and beyond. In keeping with Kauffman's assertion that at a certain level of complexity a state shift, or 'phase transition' occurs, and autocatalytic sets suddenly arrive (usually at around 50% saturation as we saw in the example of the buttons), Bergson suggests that the appearance in nature of the eye can only be perfect: 'In reality, the cause, though more or less intense, cannot produce its effect except in one piece, and completely finished.' Whether or not it is a simple eye, 'the rudimentary eye of a Serpula,' or 'the marvelously perfected eye of the bird,' it is an eye – there is not a partial eye, and animals from right across the spectrum share this amazing organ, because it is what gives them vision.[163]

On bifurcation points, deconstruction, and the shortest description

The contrast between manufacture and organisation, indeed, brings us to another key aspect of the dissipative structures, with autocatalytic autonomy, that emerge, clustered around their attractors, in complex situations where there are multiple possibilities. These structures have a history. They begin, unfold – sometimes in quite wobbly or fuzzy fashion, held homeostatically together – and can, if a perturbation proves too great, suddenly end, morphing into some entirely new state. Moreover, this history – because it is emergent, and the history of such a structure is independent of its constituents – cannot be predicted by its internal causes.

This is down to a further quality of non- or far-from-equilibrium states that must be considered, and which renders them not just difficult but impossible to predict: 'bifurcation points.'[164] In equilibrium or near-equilibrium states, the control of individual parameters has direct and predictable bearing upon whether the one steady state of that system will be maintained or broken. Make changes to one or more of those parameters and the system will move away from equilibrium, and closer to chaos. At some point a threshold of stability is reached and a 'bifurcation point' appears: the system can go in one of a number of different directions. Remembering our 'attractors' and the 'steady-states' that systems – such as the light bulb circuit – may adopt around them, maintaining homeostatic stability amidst perturbations, let us now change the parameters such that fluctuations can push the system away from this steady-state. As the parameters are changed, at a certain point – the bifurcation point – two (or more) new stable solutions can emerge. Here, then, there is a 'choice' between possibilities: how will the system choose between them? 'There is' as Prigogine describes it, 'an irreducible random element; the macroscopic equation cannot predict the path the system will take.'[165] Nor will microscopic descriptions help. God plays dice, again. Nor do we find, when repeating the experiment a number of times, a statistical probability that the system will go 50% of the time one way, 50% the other. On the contrary, such symmetry seems to elude most such systems in the natural world. Louis Pasteur in fact thought that such dissymmetry was the very characteristic of life.[166] Shells, fern leaf ends, and a whole host of other natural phenomena seem to prefer to spiral one way rather than the other: even the DNA helix is always right-handed. Prigogine suggests that it may be gravitation that is at the root of such a preference, and that nonequilibrium has magnified its effect. What is clear is that nonequilibrium systems are extraordinarily sensitive, and unpredictable: very close to the edge of chaos. It is the environmental factors, moreover – the external parameters causing fluctuations in the state space – that are key to the 'histories' of these systems.

External, 'open system' factors determine the unfolding, and in such a way that it is irreducible. The history of a dissipative structure cannot be told in any way other than by recounting its every moment, the directions it took at bifurcation points completely unpredictable based upon its previous states, let alone its constituent parts. A manufactured structure – by definition – cannot behave in this manner, and is clearly explainable from start to finish by dint of what was put into it. A self-organised structure, by contrast, is very different: it *endures*; one might say its complexity incorporates duration.

Another way to comprehend this distinction, is to use the terms given it by Cilliers in 1998. For manufacture, read complicated; for organised, read complex. If a system – despite the fact that it may consist of a huge number of components – can be given a complete description in terms of its individual constituents, such a system is merely complicated. Things like jumbo jets or computers are complicated. In a complex system, on the other hand, the interaction among constituents of the system – and the interactions between the system and its environment – are of such a nature that the system as a whole cannot be fully understood by analysing its components. Moreover, these relationships are not fixed, but shift and change, often as a result of self-organisation. This can result in novel features, usually referred to in terms of emergent properties. The brain, natural language and social systems are complex.[167]

There are, moreover, important differences in approach that must be undertaken between studying something that is complicated, and something which is complex. The analytical method, whilst useful for complicated systems – and for manufacturing them – is counterproductive when trying to understand complex systems. Complexity focuses on the shifting and evolving 'intricate relationships' between components. 'In "cutting up" a system, the analytical method destroys what it seeks to understand.'[168] Furthermore, concentrating on neural networks, Cilliers points out that these interactions are not restricted to being physical – they can also be described as 'transference of information.'[169] These interactions are both rich – 'any element in the system influences, and is influenced by, quite a few other ones', and non-linear – 'small causes can have large results, and vice versa. It is a precondition for complexity.'[170] As we saw with the buttons and threads, the interconnections can suddenly produce massive clusters. If the threads are seen as electrochemical connections and the buttons as neurons, then Cilliers' picture gives us an approximation of how complex patterns might unfold within the neural networks of the brain. These rich, non-linear information exchanges, moreover, are short-range, resulting in the phenomenon of recurrency. Information being received primarily from each component's immediate neighbours (whether neurons, buttons or light bulbs), can go through many 'hops', resulting in wide-ranging influence, and there can be 'loops in the interactions' – activities can affect themselves through direct feedback or after a number of intervening stages.[171] Such 'feedback' can be positive (enhancing, stimulating) or negative (detracting, inhibiting). Both kinds are necessary. Complex systems are 'open systems, i.e. they interact with their environment.' By contrast, 'closed systems are usually merely complicated.'[172]

As Cilliers stresses, 'Complex systems operate under conditions far from equilibrium. There has to be a constant flow of energy to maintain the organisation of the system and to ensure its survival. Equilibrium is another word for death.'[173] This constant flow of energy is Prigogine's 'dissipative structures,' Bergson's unceasing expenditure of energy. As Kaufmann puts it, 'in dissipative systems, the flux of matter and energy through the system is a driving force generating order.'[174] It is here, in this inherently unstable nonequilibrium, where, according to Kaufmann, 'life exists at the very edge of chaos.'[175] Living cells, then, are themselves 'nonequilibrium dissipative structures', and the very nature of evolution – and especially of the coevolution of many systems, such as species in an environment – is to attain the '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.'[176]

As Cilliers underlines, such 'complex systems have a history. Not only do they evolve through time, but their past is co-responsible for their present behaviour.'[177] Unlike merely complicated systems, susceptible to analysis, this order does not arise through the control of one part of the system over another.

> Each element of the system is ignorant of the behaviour of the system as a whole, it responds only to information that is available to it locally. This point is vitally important. If each element 'knew' what was happening to the system as a whole, all of the complexity would have to be present in that element.[178]

Here we return again to the distinction between complicated and complex, between manufacture and organisation. What becomes apparent is that, whilst the former can be described, often axiomatically, in pithy formulae – to the chagrin of Hutchinson, Lindemann, the Odum brothers and many other mid-20th century ecologists and their project to mathematicise life's processes – the complex – the organised – is not susceptible to measurement in this manner.

Echoing Bergson's comments (though he does not reference Bergson), Cilliers argues 'that philosophy has an important role to play, not by providing a meta-description of that which happens in science and technology, but by being an integral part of scientific and technological practice. Specific philosophical perspectives can influence the way we approach complex systems.'[179] Poststructuralist approaches, Cilliers argues, can and do chime well with certain kinds of scientific endeavour, such as complexity theory, and can bring great benefits. His argument concerns the – very Derridean – deconstruction of the distinction between inside and outside:

> In a representational system the representation and that which is being represented operate at different logical levels – they belong to different categories. This is not the case with a neural network. There is no difference in kind between the sensory traces entering the network and the traces that interact inside the network. In a certain sense we have the outside repeated or reiterated on the inside thereby deconstructing the distinction between outside and inside. The gap between the two has collapsed.'[180]

We are reminded of Bergson's explication of perception, and how this too deconstructs the distinction between inside and outside. 'The "logic" of the trace disturbs both the representation (inside) and the to-be-represented (outside). When the closure of the inside is breached, we discover a different mimesis, one that is constituted by a reflexive process of mutual definition. The inside and the outside become intertwined.' [181] Bergson's own words are similar – pure perception, we may recall, is always in the absolute present, intuitively grasped, and existing ultimately outside of us – in the objects that we perceive.

So we can begin now to form a (moving) picture of the *durée complexe*. It is clear that, as emergent dissipative structures – passing through transition phases and bifurcation points, simply not susceptible to the analytical method of reductive logic, and beyond the possibility of prediction from their constituent parts – complex adaptive systems require a very different mindset, for their understanding, to that of traditional positive science. They are irreversible, with only statistical probability to describe their next move, which could be either within a homeostatically stable cycle or off down some new trajectory toward an avalanche of new potentialities. The contingent, contextualised, distributed nature of their edge-of-chaos order – gathering energy together counter to the downward drag of entropy – means that the structural properties of their environments have more to say about them than their constituent parts; and those structures are themselves contingent on other structures, both contained by, beside, and containing them – to the point at which what is inside or outside of them becomes indistinguishable.

Ultimately, as Kaufmann asserts, the fundamental problem with reductionist thought, when applied to complex systems, is that to represent a complex system one must, of necessity, reproduce the system in its entirety. The representation, usually something like an algorithm – the '*shortest description*' which can capture the essential elements of a system – can only capture the entirety of a complex system, because a complex system is already its own shortest description. In computation this is known as an 'incompressible algorithm'.[182]

On explosive emergence and the *élan vital*

This notion of the 'shortest description' – that the complex, the organised, emergent dissipative structure with its own history can only be represented in its entirety – conjures a living universe very reminiscent of the manner in which the *durée réelle* unfolds: the immediate present, grasped as a whole by the *intuitive* faculty, takes part in the durational succession of the universe, pregnant with the memory of the past that has gone – if only to constitute the novelty of the present – and poised to choose from the indeterminate possibilities of the future. Where such novelty and indetermination exist, the 'shortest description' of reality can only be its complete retelling. Any algebraic formula that could predict such an unfolding system would by definition reduce it to a predictable, predetermined, closed system: something complicated, manufactured. The concept of the 'shortest description' in complexity theory presupposes, in fact, the emergence of novelty in a durational understanding of time.

Taken as a whole, then, living systems interpenetrating and interrelating as duration unfolds, we are witness to two opposing forces: the complicated, manufactured, physical nature of the inert material universe as it gradually winds its way down the thermodynamic stairway of entropy to heat-death; and, moving in the opposite direction, the self-organising principle of living, dissipative structures held homeostatically in extraordinarily complex ordered states at the edge of chaos by the attractors that keep them from tipping over its edge. Bergson could hardly have put it better.

This self-organising tendency Kaufmann describes as 'explosive emergence'. Bringing nonequilibrium thermodynamics, statistical physics, and biology together, the work of young British biochemist and physicist Jeremy England, at MIT, is today suggesting that this 'explosive emergence' is in fact an inherent physical property of Prigogine's dissipative structures: that internal organisation and self-replication are statistically probable in such energy-driven conditions. For England, in other words, thermodynamic systems increasing the entropy around them in order to maintain internal order – all living things – do so even more efficiently by increasing structural organisation and self-replicating.[183] Thus, the origin and subsequent evolution of life follow from the fundamental physical laws of the universe – and the ability to capture energy and dissipate it as heat is the defining skill which differentiates the living from the inert.

Bergson's own story of vegetation capturing solar energy as the core engine of life comes to mind. Indeed, Kaufmann's 'explosive emergence' and England's underlying physical principle driving the origin and evolution of life, one might equally term the *élan vital*. As Bergson told us, a century ago, also using the image of an explosion, the force of evolution works in the opposite direction to entropy, unfolding like a sheaf. 'All our analyses show us, in life, an effort to remount the incline that matter descends,'[184] he says, 'Incapable of *stopping* the course of material changes downwards, it succeeds in *retarding* it.'[185] The thermodynamic heat-death of entropy, in other words, which brought history into physics in the 19th century, is *opposed* by the force of life – at the very edge of chaos – in the manner in which dissipative structures emerge – seemingly with an inevitability shown by statistical physics – at that edge. As Bergson describes it, 'In vital activity we see, then, that which subsists of the direct movement in the inverted movement, *a reality which is making itself in a reality which is unmaking itself*.'[186]

On ecological complexity

Following on from the work of Botkin, Goodwin and Kaufmann, an entire field of enquiry has opened up, with its own journal, *Ecological Complexity,* and foundational books such as by May,[187] Allen and Starr,[188] and Maurer,[189] along with the magnificent work Gould had so much praise for that is ongoing at the Santa Fe Institute,[190] which explores all of complexity theory, not just the ecological kind. Many of these scientists consider, as Levin puts it, that ecological systems are the prototypical complex adaptive systems.[191] This ecological field is, as far as I can tell, as a layman looking in, still replete with many of the kind of mechanics-driven attitudes ecology was encased within for much of the 20th century, but is also clearly driving forwards into new and little charted territory, and should be applauded for its courage and for the thoroughness with which it is refusing to completely drop what has gone before, but instead attempt to bring the best of it into a new understanding, whilst sloughing off the worst of its dogmatic rigidity. Its relatively newfound insistence on the rigours of fieldwork and empirical proofing is much to be admired, after so many years of trying to make the facts fit the theories.

My own view, nonetheless, approaching this subject from the perspective of philosophy, is that there remain some hard to shake attitudes – not least to the role of philosophy, and what part it may play: note Waldrup's desire, in his story of the Santa Fe institute, to avoid 'sterile philosophising' as if it were on a par with the 'New Age mysticism'[192] he also wishes to avoid. It is with respect to the understanding of time, key to the understanding of life, and of living systems, that these scientists remain stuck, all too often, in the mechanistic frame, where in many other respects they have been instrumental in moving on from it. Ultimately, with time, one must also allow consciousness – that which experiences duration, the memory inherent in durational succession – and this, in science, for all the impossible paradox of epiphenomenality, seemingly remains taboo.

Does ecological complexity's exploration of network dynamics with their state-spaces, attractors and 'order for free' constitute a computational approach to the philosophical leap of imagination by which

Bergson saw that duration – the unfolding of number in action – was a truer representation of the real than the spatial, sequential numbering of conventional measure? The 'order for free' in the network dynamics Kauffman describes is a property of numerical relationships only observable in the unfolding of sequences, patterns apparent in duration, and not in the relationship between numbers that are spatially conceived. Process is paramount, but all too often cannot be simply mapped in a process chart. When Kauffman describes order as existing in a corner of a 'state space', does he return to spatial conception, and would he not perhaps better conceive this 'order for free' as a durational clustering around the ordering, self-organising principle of the *élan vital* – as a duration rather than as a space? If England has indeed found the physical driving force that makes the living from inert matter, and pushes it into ever further structural order through self-replication – moulded, as he of course is keen to assert, by Darwinian natural selection – then is not that physical driving force, proof of the inevitability of life, also reason for us to consider that life is, not only no longer an accident of the universe, but its ultimate principle? If it is indeed inevitable, inherent in the physical properties of matter, is it not therefore also conceptually prior to matter, as much as its outcome, in the way Bergson describes the universe on the model of consciousness?

If the edge of chaos is in fact where complex systems nudge towards as an optimal – if precarious – state allowing both stability and flexibility, is not the indetermination of centres of action, the places where Bergson describes that animal – and human – consciousness exists, itself at the edge of chaos, where choice takes place, amplifying microphysical indetermination?

Consciousness, in other words, must be considered if the development of the complexity sciences is to be truly radical, and finally grasp at an understanding of reality. For all that many of our choices, inevitably constrained by the range of the possible, may seem at times predictable – and the study of social media would suggest that many of our reactions and responses, at least *en masse*, can be quite accurately second-guessed[193] – nonetheless the most important moral, ethical, political, philosophical and scientific developments in history are always the result of innovation, of choices not made before, and the rippling consequences of such actions: it is Bergson's *intuition philosophique* which gives us these pushes forward, for all that, as Foucault would assert, the insights appear within the wider discourse, as we saw in Chapter 4, rather than solely in the minds of single individuals. Just as a butterfly's wings can, without warning, cause global ramifications, so the choices of individuals, *because* they are located in complex and contingent social contexts, can turn history one way or another. Such indetermination cannot be left out of the picture. It is clearly a core driver, and not just of social change: at the level of the species, no less, humanity is right now making massive geophysical changes to our home planet.

There are challenges, in sum, as well as consonances, between Bergson's ideas and those of ecological complexity; and I leave it to the complexity scientists to explore them, if they dare.

Notes

1. See Waldrop M. M. (1993) *Complexity: The Emerging Science at the Edge of Order and Chaos* New York: Simon and Schuster
2. Carr, H. W. (1919) *Henri Bergson: the Philosophy of Change* London: T. Nelson and Sons, available from the Internet Archive https://ia600305.us.archive.org/11/items/henribergsonphil00carruoft/henribergsonphil00carruoft.pdf p. 14
3. Mullarkey, J. (1999) *Bergson and Philosophy* Edinburgh: Edinburgh Press pp. 1–8
4. *CE* pxxiv
5. Kauffman, S. (1995) *At Home in the Universe* Oxford: OUP
   Kauffman, S. (2000) *Investigations* Oxford: OUP
6. Goodwin, B. (1994) *How the Leopard Changed its Spots* New York: Charles Scribner & Sons
7. Botkin, D. (1992) *Discordant Harmonies* Oxford: OUP
8. Prigogine, I., & Nicolis, G. (1977) *Self-Organization in Non-Equilibrium Systems*. London: Wiley.
   Prigogine, I., & Stengers, I., (1985) *Order out of Chaos*. London: Flamingo
   Prigogine, I. (1996) *The End of Certainty: Time, Chaos and the New Laws of Nature* New York: The Free Press
9. Castellani, B., and Hafferty, F. (2009) *Sociology and Complexity Science* Berlin: Springer-Verlag p. 16
10. Kauffman, S. (1995) *At Home in the Universe* Oxford: OUP p. 9
11. *CE* p. 112
12. Kauffman, S. (1995) *At Home in the Universe* Oxford: OUP p. 90
13. Cilliers, P., (1998) *Complexity and Postmodernism* London: Routledge
14. Prigogine, I., & Stengers, I., (1985) *Order out of Chaos*. London: Flamingo p. 104
15. Ibid. p. 104
16. Ibid. p 105
17. Ibid. pp. 107–108
18. Ibid. p. 108
19. Ibid. p. 111
20. Ibid. p. 112

21. Ibid. p. 115
22. Ibid. p. 115
23. Ibid. p. 10
24. Ibid. p. 92
25. Ibid. pp. 92–93
26. Crooks, G. E. (1999) Entropy production fluctuation theorem and the nonequilibrium work relation for free energy differences *arXiv:cond-mat/9901352 [cond-mat.stat-mech]* http://arxiv.org/pdf/cond-mat/9901352v4.pdf
27. I am indebted to Pillitteri, A. L. *Modern Physics Written For The Layman: An Introduction To Special Relativity, General Relativity, And Quantum Mechanics* University of Delaware for clarity in this respect.
28. Goodwin, B. (1994) *How the Leopard Changed its Spots* New York: Charles Scribner & Sons p. 106
29. Prigogine, I., & Stengers, I., (1985) *Order out of Chaos*. London: Flamingo p. 215
30. Ibid. p. 215
31. Ibid. p. 215
32. Duhem (1914[1906]) The Aim and Structure of Physical Theory p24, as quoted in Torretti, R. (1999) *The Philosophy of Physics* Cambridge: Cambridge University Press. pp. 242–243.
33. Pillitteri, A. L. *Modern Physics Written For The Layman: An Introduction To Special Relativity, General Relativity, And Quantum Mechanics* University of Delaware
34. Deleuze, G. (1991[1966]) *Bergsonism*. New York, Zone Books. pp. 39–40
35. Weyl. H. (1952) *Space, Time, Matter*. Transl. Henry L. Brose. New York: Dover Publications.
36. *DS* pp. 71–72
37. See Dingle, H. (1922) *Relativity for All* Boston: Little Brown, https://archive.org/details/relativityforal00dinggoog
38. Dingle, H. (1962) 'Special Theory Of Relativity', *Nature* 195, pp985–986; Dingle, H. (1963) 'Special Theory Of Relativity', *Nature* 197, pp1248–1249; and Dingle, H. (1967) 'Special Theory Of Relativity', *Nature* 216, pp. 119–122.
39. *MM* p. 194
40. *DS* p. 113
41. Canales, J (2005) Einstein, Bergson, and the Experiment that Failed: Intellectual Cooperation at the League of Nations *Modern Language Notes* 120 p. 1169
42. Ibid. p. 1176
43. Ibid. p. 1176
44. Ibid. p. 1177
45. Prigogine, I., & Stengers, I. (1985) *Order out of Chaos*. London: Flamingo p. 227
46. Botkin, D. (1992) *Discordant Harmonies* Oxford: Oxford University Press p. 123
47. Prigogine, I., & Stengers, I. (1985) *Order out of Chaos*. London: Flamingo p. 228
48. *MM* p. 266
49. *MM* p. 276
50. *CE* p. 206

51. de Broglie, L. (1969[1947]) The concept of contemporary physics and Bergson's Ideas on Time and Motion, in *Bergson and the evolution of physics,* Pete A.Y. Gunter (Ed. and trans.) Knoxville: University of Tennessee Press, p47. This essay appeared originally in 1947 in Louis de Broglie's book *Physique et Microphysique* which was translated and published in English in 1955 by Pantheon Books as *Physics and Microphysics*.
52. Ibid. p. 45
53. Botkin, D. (1992) *Discordant Harmonies* Oxford: OUP p. 123
54. de Broglie, L. (1969[1947]) The concept of contemporary physics and Bergson's Ideas on Time and Motion in, *Bergson and the evolution of physics,* Pete A.Y. Gunter (Ed. and trans.) Knoxville: University of Tennessee Press, p. 45
55. Ibid. p. 45
56. Ibid. p. 49
57. Ibid. p. 50
58. *CE* pp367–368, quoted by de Broglie, L. Ibid. p. 50
59. *CE* p. 368
60. de Broglie, L. (1969[1947]) The concept of contemporary physics and Bergson's Ideas on Time and Motion, in *Bergson and the evolution of physics,* Pete A.Y. Gunter (Ed. and trans.) Knoxville: University of Tennessee Press, p. 50
61. Ibid. p. 50
62. Ibid. p. 50
63. Ibid. p. 51
64. Ibid. p. 52
65. Ibid. p. 53
66. Ibid. p. 53
67. Ibid. p. 54
68. Ibid. p. 56
69. See Earman, J. (2004) Determinism: What We Have Learned and What We Still Don't Know, in J.K. Campbell, M. O'Rourke and D. Shier eds (2004). *Freedom and Determinism*, Topics in Contemporary Philosophy Series, vol. II, Cambridge, MA and London: MIT Press, for a longer discussion of determinism in various physical theories, and the continued lack of definitive answers to these questions.
70. *ME* p. 7
71. *CE* p. 123
72. *CE* p. 199
73. *CE* p. 199
74. *ME* p. 8
75. *CE* p. 296
76. *CE* p. 259
77. *CE* p. 259
78. *CE* p. 259
79. *CE* p. 204
80. Čapek, M. 'Bergson's Theory of the Mind–Brain Relation' in Papanicolaou, A. and Gunter, P. eds (1987). *Bergson and Modern Thought* Chur: Harwood Academic Publishers p. 138
81. Bjelland, A. G. 'Durational Succession and Proto-Mental Agency' in Papanicolaou, A. and Gunter, P. eds (1987). *Bergson and Modern Thought* Chur: Harwood Academic Publishers p. 21

82. Čapek, M. (1961) *The Philosophical Impact of Contemporary Physics* Princeton: D. Van Nostrand Co. pp. 339–340
83. Prigogine, I., & Stengers, I. (1985) *Order out of Chaos*. London: Flamingo p. 52
84. Ibid. p. 52
85. *CE* p. 296
86. Bohr, N (1987[1931]) *Atomic Theory and the Description of Nature*, Vol 1, Woodbridge, CT: Oxbow Press. p. 117
87. Bohr, N. (1957) 'Physical Science and the Problem of Life', rpt. in *Essays, 1932–1957, on Atomic Physics and Human Knowledge* (cit. n. 1), Woodbridge, CT: Oxbow Press. pp. 94–101
88. Čapek, M. 'Microphysical indeterminacy and freedom: Bergson and Pierce.' In Burwick, F. and Douglass, P. eds (1992) *The Crisis in Modernism: Bergson and the Vitalist Controversy* Cambridge: Cambridge University Press p. 171
89. Čapek, M. 'Bergson's Theory of the Mind–Brain Relation' in Papanicolaou, A. and Gunter, P. eds (1987). *Bergson and Modern Thought* Chur: Harwood Academic Publishers p. 130
90. Ibid. p. 130
91. Ibid. p. 132
92. Ibid. p. 133
93. Ibid. p. 133
94. Papanicolaou, A., & Gunter, P. (1987) *Bergson and Modern Thought* Chur: Harwood Academic Publishers pxix
95. *CE* p. 385
96. Schrödinger, E. (1944) *What is Life?* http://whatislife.stanford.edu/LoCo_files/What-is-Life.pdf
97. *CE* p. 430
98. von Foerster, H. (1974), *Cybernetics of Cybernetics*, Urbana Illinois: University of Illinois
99. von Foerster, H. Mora, P. M., & Amiot, L. W. (November 1960). 'Doomsday: Friday, 13 November, A.D. 2026. At this date human population will approach infinity if it grows as it has grown in the last two millennia.' *Science* 132 (3436): 1291–1295.
100. Maturana, H. R. (1970) 'Biology Of Cognition'. Biological Computer Laboratory Research Report BCL 9.0. Urbana IL: University of Illinois. As Reprinted in: *Autopoiesis and Cognition: The Realization of the Living*. Dordecht: D. Reidel Publishing Co., 1980, pp. 5–58. See also Maturana, H. R. & Varela, F. J. (1987) *The Tree of Knowledge* Boston, MA: Shambhala Publications
101. Luhmann, N. (1986) 'The Autopoiesis of Social Systems.' pp. 172–192 in Geyer, F., & Van d. Zeuwen, J. eds *Sociocybernetic Paradoxes: Observation, Control and Evolution of Self-Steering Systems*. London: Sage.
102. Jessop, B. (1987) *Economy, State and Law in Autopoietic Theory* Issue 42 of Essex papers in politics and government, University of Essex.
103. Simon, H. (1962) The Architecture of Complexity. *Proceedings of the American Philosophical Society*. Vol. 106(6)
104. Kallinikos, J. (2006) *Complexity and information systems development: A comment on Benbya and McKelvey*. http://personal.lse.ac.uk/kallinik/docs/BenbyaMckelvey.doc (accessed 9/12/13)

105. See Padgett, J. F. (2012) 'Autocatalysis in Chemistry and the Origin of Life' in John F. Padgett and Walter W. Powell (2012) *The Emergence of Organizations and Markets* Princeton, NJ: Princeton University Press pp. 33–69
106. Pask, G. (1975) *Conversation, cognition and learning*. New York: Elsevier.
107. Beer, S. (1959) *Cybernetics and Management*, London: English Universities Press
108. Latour, B. (1993) *We Have Never Been Modern* Edinburgh: Pearson
109. Goodwin, B. (1994) *How the Leopard Changed its Spots* New York: Charles Scribner & Sons p. 105
110. Prigogine, I., & Stengers, I. (1985) *Order out of Chaos*. London: Flamingo p. 142
111. Ibid. p. 143
112. Ibid. p. 143
113. Goodwin, B. (1994) *How the Leopard Changed its Spots* New York: Charles Scribner & Sons p10
114. Prigogine, I., & Stengers, I. (1985) *Order out of Chaos*. London: Flamingo p. 121
115. Ibid. p. 121
116. Kauffman, S. (1995) *At Home in the Universe* Oxford: OUP p. 78
117. *CE* p. 133
118. *CE* p. 133
119. *CE* p. 116
120. *CE* p. 116
121. Watson J. D. and Crick F. H. C. (1953). 'A Structure for Deoxyribose Nucleic Acid'. *Nature* 171 (4356): 737–738.
122. http://www.genome.gov
123. Dawkins, R. (1989). *The Selfish Gene*. Oxford: Oxford Paperbacks.
124. Goodwin, B. (1994) *How the Leopard Changed its Spots* New York: Charles Scribner & Sons pp. 32–33
125. Kauffman, S. A. (2006) Beyond Reductionism: Reinventing The Sacred http://edge.org/conversation/beyond-reductionism-reinventing-the-sacred
126. Goodwin, B (1994) *How the Leopard Changed its Spots* New York: Charles Scribner & Sons p. 33
127. Ayyanathan, K. (2014) *Specific Gene Expression and Epigenetics: The Interplay Between the Genome and Its Environment* Oakville: Apple Academic Press
128. Botkin, D. (1992) *Discordant Harmonies* Oxford: Oxford University Press p. 9
129. Ibid. p. 9
130. Ibid. p. 7
131. Sullivan, S., & Rohde, R. (2002) On non-equilibrium in arid and semi-arid grazing systems. *Journal of Biogeography*, 29, 1595–1618
132. Goodwin, B. (1994) *How the Leopard Changed its Spots* New York: Charles Scribner & Sons p. 33
133. Ibid. p. 35
134. Ibid. p. 35
135. Ibid. p. 36
136. Ibid. p. 36
137. Belousov, B. P. (1959). Periodically acting reaction and its mechanism *Collect Abstr Radiat Med* 147: 145, and Zhabotinsky, A. M. (1964). Periodical process of oxidation of malonic acid solution. *Biophysics* (9) 306–311

138. Winfree, A. (1987) *When Time Breaks Down: The Three-Dimensional Dynamics of Electrochemical Waves and Cardiac Arrhythmias* Princeton, N.J.: Princeton University Press.
139. Kauffman, S. (1995) *At Home in the Universe* Oxford: OUP pp. 53–54
140. Kauffman, S. A. (1969) Metabolic Stability and Epigenesis in Randomly Constructed Genetic Nets *Journal of Theoretical Biology* (22), 437–467
141. Kauffman, S. A. (1971) Cellular Homeostasis, Epigenesis, and Replication in Randomly Aggregated Macromolecular Systems. *Journal of Cybernetics* 1, 71–96
142. Goodwin, B. (1994) *How the Leopard Changed its Spots* New York: Charles Scribner & Sons p. 47
143. Ibid. p. 46
144. Ibid. p. 47
145. Kauffman, S. (1995) *At Home in the Universe* Oxford: OUP p. 56.
146. Ibid. p. 75
147. Ibid. p. 77
148. Ibid. p. 77
149. Ibid. pp. 77–78
150. Kauffman, S. A. (1971) Cellular Homeostasis, Epigenesis, and Replication in Randomly Aggregated Macromolecular Systems. *Journal of Cybernetics* 1, 71–96 and Kauffman, S (1995) *At Home in the Universe* Oxford: OUP p. 57
151. Kauffman, S. (1995) *At Home in the Universe* Oxford: OUP pp. 90–91
152. *CE* p. 109
153. Kauffman, S (1995) *At Home in the Universe* Oxford: OUP p. 69
154. Ibid. p. 42
155. Ibid. p. 69
156. *CE* p. 102
157. Goodwin, B. (1994) *How the Leopard Changed its Spots* New York: Charles Scribner & Sons p. 116
158. Kauffman, S. (1995) *At Home in the Universe* Oxford: OUP p. 9
159. Ibid. p. 114
160. *CE* p. 99
161. *CE* p. 109
162. *CE* p. 103
163. *CE* p. 106
164. Prigogine, I., & Stengers, I., (1985) *Order out of Chaos*. London: Flamingo p. 160
165. Ibid. p. 162
166. Ibid. p. 163
167. Cilliers, P. (1998) *Complexity and Postmodernism* London: Routledge p. viii
168. Ibid. p. 2
169. Ibid. p. 3
170. Ibid. p. 3
171. Ibid. p. 4
172. Ibid. p. 3
173. Ibid. p. 3
174. Kauffman, S. (1995) *At Home in the Universe* Oxford: OUP p. 21
175. Ibid. p. 26
176. Ibid. p. 29

177. Cilliers, P. (1998) *Complexity and Postmodernism* London: Routledge p. 4
178. Ibid. p. 4
179. Ibid. p. 2
180. Ibid. p. 83
181. Ibid. p. 84
182. Kauffman, S. (1995) *At Home in the Universe* Oxford: OUP p. 22
183. England, J. (2013) Statistical physics of self-replication *Journal of Chemical Physics* 139, 121923
184. *CE* p. 268
185. *CE* p. 268
186. *CE* p. 270
187. May, R. M. (1973) *Stability and Complexity in Model Ecosystems* Princeton, NJ: Princeton University Press
188. Allen, T. F. H., & Starr, T.B. (1982) *Hierarchy: Perspectives for Ecological Complexity* Chicago, IL: University of Chicago Press
189. Maurer, B. A. (1999) *Untangling Ecological Complexity: The Macroscopic Perspective* Chicago, IL: University of Chicago Press
190. See http://www.santafe.edu
191. Levin, S. A. (1998) Ecosystems and the biosphere as complex adaptive systems. *Ecosystems* 1:431–436.
192. Waldrop M. M. (1993) *Complexity: The Emerging Science at the Edge of Order and Chaos* New York: Simon and Schuster p289
193. Kreps, D. (2014) WhatsApp: Even private chatter now exploited by billionaires *The Conversation 21/2/2014* http://theconversation.com/whatsapp-even-private-chatter-now-exploited-by-billionaires-23550

6
Creative Emergence

In this final chapter, I wish to present, not a new and further treatment or exegesis, but rather a brief conclusion and summary, and a rounding off of this volume with the sketch of a final idea that draws the others together: *creative emergence*.

Bergson's core message and legacy

I suggested in the introduction that perhaps Bergson's primary task – the idea that drove him – was to promote an openness of spirit, which he himself espoused, both in his philosophical and political projects. He never claimed to be putting forward a coherent – for which read 'closed' – philosophical system, and indeed professed a desire to begin each new work with as clean a slate as possible, mindful that in the years since his previous book his ideas – and the world – will have moved on, and each new work should reflect this.[1] Arguably the disdain for the 'author' expressed by poststructuralists in the 1960s was in part an echo of this, and complaints that the oeuvre – say, of Michel Foucault and others – lacks coherence, neglects this aspect of their approach to their work. Duration is lived experience, and Bergson's ideas were as much a methodology for moving forward, a spirit of inclusive inquiry that desired the best from wherever it might arise, as an attempt to lay out philosophical ideas: his presidency of the ICIC, precursor to UNESCO, was just such a project – Bergson set himself against all closed and rigid systems of thought.

His principal message was that philosophy should retain a place in the intellectual pursuits of society, and that the claims of logic, rationalism – and especially physics – should not try to overstep their proper area of concern. He never suggested that the fruits of *intuition* should not be tested, but insisted that the greatest ideas in the history of science had come through the freedom to *intuit*.

His own, truly 'great' idea was the notion of the *durée réelle,* of real time, and his life's work the application of that idea to the science of his day. For all that the possible is constrained – and in the power/knowledge matrix that Foucault's later poststructuralism gave us those constraints can seem all too suffocating – nonetheless *lived* time exists at the threshold of many potential futures, and it is – as even Foucault was to admit in later life – conscious choice which can, if we are mindful, determine which way things will unfold. Bergson was lucid and clear where he stood in the determinism/indeterminism debate: there are centres of action within the multiple fields of cause and effect, where prime causes can be chosen and enacted; those centres of action are ourselves. He never suggested we were capable of this all of the time – indeed it takes some effort, and in a whole lifetime there might be precious few moments when such real choices might be made: but they can be, and are, and this is the indetermination that makes us human.

His solutions for all the profound questions of life were always temporal, concerning mobility, movement, and change. The first 'process' philosopher, this accent upon activity and mobility won over Bertrand Russell's co-author, Alfred North Whitehead, whose own process philosophy thereafter left the static, abstract logic of his youth behind. The key insight is that, in a world where there is no consciousness to perceive duration, the universe as represented by the equations of physics might just as easily take one second as 15 billion years to run from beginning to end. For there to be a purpose – an evolutionary necessity – for consciousness, it must play a part in that unfolding: and not merely as observer, nor as merely an effect. Durational quality must sit alongside, the other side of the coin, to manifest quantity, for the totality of the universe to be realised.

Bergson's universe is thus utterly infused with consciousness – because the universe *endures* – and consciousness, once admitted, perforce becomes the primary aspect of a universe that would otherwise simply run down the stairway of entropy. Consciousness acts to generate life, which runs up in the opposite direction, a gathering, ordering principle running counter to the determined collapse of the inert. Life, driven by the *élan vital,* the principle of ordering, is that universal consciousness, acting through life upon inert matter, becoming, at the last, through us, self-aware. We are not nature's perfection, nor indeed the best possible outcome, let alone inevitable. But we are, for Bergson, that which the universe is ultimately for. Crucially, the moral message is that we have a duty to make the best of it, and to do so together, and not in closed silos keeping each other out.

Bergson's impact upon the history of 20th century thought has been – until lately – somewhat overlooked, but profound. Even those authors who never mentioned or credited him, whose own ideas had profound impact, were schooled in his ideas before ever they had their own.

Bergsonian complex evolutionism

The progress of 19th century mechanistic approaches to evolution, continually trying to reduce all things to the simple that one may represent upon a static graph, flying in the face of the moving multiplicity Bergson had shown us in his work, continued well into the 20th century – and, indeed, remains the 'popular' view outside of the highest scientific circles. As I have shown in my genealogy of systems thinking, bolstered by the interests of economic and political elites and through the upheavals of war, even as recently as the 1970s ecologists believed algebraic equations built upon classical dynamics told them the truth about animal populations.

But finally, then, a radically different kind of evolutionary theory began to unfold – in keeping, as I have shown, with Bergson's ideas. This new evolutionism, informed by complexity theory, shares with Bergson the principle of self-organisation in living systems, and seems in all but name the very *élan vital* of which Bergson wrote a century ago, in his *Creative Evolution*. But the role of consciousness remains, in the ecologists' new evolutionary theory, as eclipsed as it was in the old.

So, taking this new evolutionism together with Bergson's, I present here, in my final chapter, some thoughts around the possibilities of a new approach to understanding evolution: *creative emergence*. I do so in the hope that many more voices than my own will take up this challenge: as Bergson enjoined, his philosophy, unlike those of the past, entailed an attempt to emulate the community approach of the sciences. Together, we may be able to open up possibilities for a greater understanding of our place in the world, and of the nature of evolution, of time, and of our role in it. We have little time to lose.

The sciences are ripe and ready for a new philosophical approach that leads decisively and finally beyond the mechanism of the 19th century. More poststructuralist approaches are indeed far more in keeping with the discoveries of the last decades than the old Newtonian simplicity of classical dynamics and the simple chains of cause and effect. Complexity theory in particular lends itself very well to such new philosophical insights.

Poststructuralist complexity

Following Cilliers' lead, for whom complexity theory in neural networks was redolent with Derrida's collapse of subject/object, of inside and outside, complexity theory in environmental biology can be seen as a kind of poststructuralist systems thinking: the gene, the organism, and the species, as units of selection, are all decentred. The individualism of Darwin's Smithsonian competition and struggle amongst those units of selection becomes a secondary sideshow against a greater backdrop, in the same way that Saussure decoupled the word from its referent, and set language free of the chains that held it to the Enlightenment subject–object divide of Cartesianism; in the same way that Foucault decoupled the Self from the Individual Subject, to whom the Enlightenment Objective world had been revealed, and showed how each of us is in truth a composite of all our influences – a kaleidoscope of practices, knowledge, and power relations that play themselves through us. So, too, through the lens of complexity theory, we can now see how evolution unfolds as a network dynamic amongst and through populations, as a property of the gathering together of large networks of molecules, genes, organisms, and species, and the environments in which they live and intermingle. It is the structural properties, and the intermingling of these networks, and not the natural selection of individual gene/organism/species that is the primary force in evolution. It is the increasing efficiency of the dissipation of energy, that, contra such entropy, in a turning back upon itself, generates this extraordinary order.

True, in the minds of many scientists it remains a structuralist approach, in that, like Saussure, it still clings, in them, to an attempt at justifying itself in the mechanistic terms of classical science, seemingly feeling safer on 19th century ground. Indeed, there remain many ecologists for whom complex systems science (CSS) continues to be suspect. 'Despite growing recognition of the utility of CSS in many disciplines, the field of ecological complexity has yet to be widely adopted by ecologists and remains controversial to many,'[2] as one recent paper tells us. But, as philosopher of complex systems, Cliff Hooker, asserts, 'The world has turned. The old orthodox framework for science that sufficed for the study of simpler systems ... no longer suffices.'[3]

The true promise of complexity is that it can – and should – rest on the far less certain ground of the new physics. The network dynamics of complex systems is – as Gould acknowledges – the best explanation we yet have for the origin of life, in the primordial soup of autocatalytic sets of molecules, although England's ideas may yet confirm that statistical physics makes such network dynamics inevitable at a microphysical and thermodynamic level below the molecular. Whilst dissipative structures do exist in inert conditions – the flow of water from the tap – everything we regard as *living* is certainly a dissipative structure with complex behaviours. Complex ecology, then, can and should fully acknowledge, in the macroscopic scale of life, the inherent unpredictability, irreversibility, and indetermination in the extraordinary order that emerges in far-from-equilibrium conditions at the edge of chaos. As such, life does indeed amplify the microphysical indetermination of the new physics, as Niels Bohr himself suggested. The statistical probabilities and precarious homeostases in which attractors hold life's ordered states are indeed all too often extremely fragile and unpredictable. As Botkin has underlined, the real story of evolution is of constant – and continuing – change, with no 'natural' state for any component, however small or large, of the biosphere as a whole – which itself remains porous to material from meteors, comets, and the constant rain of spacedust, let alone the driving energy that turns the entire biosphere: sunlight.

In this sense, then, complex ecology becomes poststructuralist, dealing in multiplicities where difference and relation are all that there is, no 'natural' state or restful equilibrium to which ecosystems are trying to return, no solid mechanism to rely upon that could allow us to predict with accuracy, when in truth but the flap of a single butterfly's wing could set off a tumble of unpredictable outcomes flowing around the planet.[4] The biosphere is a delicate dissipative structure, obeying structural rules from the environment of the solar system, just as much as the eddies and ripples in a small brook by an entangled bank in the Kent countryside.

Bergsonian poststructuralist complex evolutionism

Crucially, like the elephant that has been in the room since Descartes covered it with invisibility paint, consciousness must play a role in this poststructuralist complex ecology. As science has – since Descartes – refused to deal with both consciousness, and its corollary, duration, it is to philosophy that we must turn, and the only[5] philosopher of the modern era who has addressed both these issues is Henri Bergson, whose critique of rationalism and focus upon mobility helped give birth to the decentring and multiplicities of poststructuralism. To Bergson, then, perforce, we must turn, to find a means by which to understand how this poststructuralist complex ecology unfolds in a time that is closer to 21st century than 19th century physics, and to Bergson, too, we must turn, for a clue as to our part within it.

Here, in the corollary of the concept of the *durée réelle,* we find the 'shortest description' of complex ecology: the unfolding of systems that cannot be reduced to a simple algorithm because of the unpredictability of the emergent features of those systems, with the result that the only description the system can bear is as long as the system's unfolding itself. Here emerges a human life, the life of a clan, of a society, of humanity, in stories that cannot be predicted from their constituents or from their histories: only probabilities exist, and, as in politics, 'events' can always steer the course. The key here is in the term, emergence, which, as we have seen, incorporates the indetermination we find at microphysical levels as well as in the bifurcation points of dissipative structures and their complex network dynamics. In the *durée réelle*, as we have seen, this very same indetermination exists, for the future is not yet, for all that the possibilities may be constrained, and when it has arrived, and one of those possibilities is the present, all the possibilities of the future are themselves changed. This emergence, this flowing duration, this unfolding of systems whose shortest description is the unfolding of the system itself all require, in the end, as we have seen, some rudimentary memory: it is a prerequisite of durational succession, that the present – which is no longer the past – nonetheless retains some element of that past by which to succeed and to differ from it. Things endure, but they also change: they emerge, and in the difference between the present and the past is consciousness.

The notion, then, of *durée complexe,* can be further developed, to present a Bergsonian complex evolutionism I describe, for want of a better phrase, as *creative emergence*. Emergent because this concept seems pivotal to ecological complexity and indeed to the very notion of open systems, as Bertalanffy argued; creative because of the consciousness inherent in the novelty, and the stories that we tell through it; and with consciousness, our place within evolution is more carefully and precisely delineated than the neo-Darwinian epiphenomenal ape whose thoughts and emotions have no causal relationship with the material universe.

Our place in this universe

All evolutionary theory, in the end – especially for the philosopher – is ultimately about where, in it all, we may find ourselves. Albeit that there is much to explore and to understand in the natural world, as Bergson says, 'Not all of these directions have the same interest for us: what concerns us is the path that leads to man.'[6]

For Goodwin, the autonomy of organisms depends – perhaps paradoxically – upon a refutation that the Darwinian/Smithsonian metaphors of 'competition, survival and selfishness'[7] are all that lie at the heart of life. Only when these metaphors become balanced on the level of the emergent organism can autonomy be truly recognised. As he tells us, 'we are every bit as cooperative as we are competitive; as altruistic as we are selfish; as creative and playful as we are destructive and repetitive. And we are biologically grounded in relationships, which operate at all the different levels of our beings, as the basis of our natures as agents of creative evolutionary emergence, a property we share with all other species.'[8] Smithsonian economics, in other words, speaks to a humanity that is isolated in its individualism: one which does not truly reflect the altruism and interrelationships we share as a species with all others.

Indeed, as Foster tells us, complex economics in fact no longer takes the individual as its unit of analysis, having moved decisively beyond the Smithsonian approach, and prefers to consider 'meso' rules – institutions, laws, norms, conventions, etc – as the core unit, providing 'an analytical perspective that recognizes, explicitly, that we are dealing with interconnected complex systems as incomplete networks of rules which facilitate individual creativity, imagination and logic in the production, distribution and consumption of goods and services.'[9] In other words, the dream of creating a sharp distinction between economics and sociology – pursued by Koopmans with von Neumann's encouragement – is now thoroughly discredited.

Kauffman suspects that 'the fate of all complex adapting systems in the biosphere – from single cells to economies – is to evolve to a natural state between order and chaos, a grand compromise between structure and surprise.'[10] His insights into how patterns in the branching of evolution reveal a lawful ordering, how the complexity of teeming variety harbours principles of self-organisation, he extends beyond the self-organisation of flora and fauna. 'The natural history of life may harbour a new and unifying intellectual underpinning for our economic, cultural, and social life,'[11] he asserts.

In *At Home in the Universe,* Kauffman mentions Bergson,[12] and the *élan vital*. He has clearly read a little about Bergson, but not read Bergson, nor understood the true nuances of *élan vital*. He shows no knowledge of the *durée réelle*. He refers to the *élan vital* as 'an insubstantial essence that permeated and animated the inorganic molecules of cells and brought them to life'.[13] This, obviously, is not an accurate representation of Bergson's ideas at all, but an implication that it was closer to the more substantival vitalists of the time, who either thought such an 'essence' was a substance yet to be isolated, or something electrical. Bergson's *élan vital*, by contrast, as we have seen, was not conceived as any kind of 'essence', whether in substance or electricity; it was, in fact, far closer to the self-organising principle Kauffman himself puts forward, or indeed the thermodynamic inevitability England suggests, and with far greater philosophical depth. There is nothing 'mysterious'[14] about Bergson's *élan vital*, as Kauffman likes to imply – again showing his ignorance of Bergson, which is a shame. As Bergson says in *Creative Evolution,* when distinguishing between animal and vegetable, 'there is no need, in order to distinguish between the two, to bring in any mysterious force,'[15] and again, when describing the upstream action of the *élan vital*, 'Creation, so conceived, is not a mystery; we experience it in ourselves when we act freely.'[16]

The reading of Bergson put forward in this book is that the *élan vital* is actually the very self-organising, explosive emergence, of which Kauffman speaks: 'We have only begun to understand the awesome creative powers of nonequilibrium processes in the unfolding universe. We are all – complex atoms, Jupiter, spiral galaxies, warthog, and frog – the logical progeny of that creative power,'[17] as Kauffman puts it; Bergson called it creative evolution. Putting the two together, I style it *creative emergence.*

Sadly, when most contemporary environmental biologists come to talk about humanity, all too often the tendency is to imagine us as clever apes – which in truth, of course, in many respects we are – but with no mention of the consciousness with which we make such comparisons. The full implications of the lesson of second-order cybernetics, *that the observer cannot be left out of the system*, seems yet to have been learnt. Such biodeterminism – the suggestion that physical processes isolated in our anatomical and biological makeup are reductively responsible for all of human culture, history, and even scientific thought – remains the 'accepted' approach of science, even amongst those scientists who are challenging such reductive approaches in everything else. The fear, no doubt, is of sounding religious – of being accused of believing that some divine force has pre-ordained the human as the perfection of His work.

But creative emergence – ecological complexity, the quantum probabilities of durational succession, the strivings of the *élan vital,* and the free choices of human 'centres of action' – is subject to indetermination: there are bifurcation points in these processes where things can go one way or another, emergent phase transitions with unpredictable outcomes, and there is little telling which way they will go. Thus, not only the mechanistic approach that would predict from previous conditions fails, but also the religiously minded finalist approach that would impute some progress toward a divinely pre-determined end fails: if the arrival of humanity is beyond prediction, so it is, too, with 'human nature', let alone 'human progress'. One thing we have learnt from the poststructuralists, who took on Bergson's notions of multiplicity and mobility and his critique of both mechanism and finalism, is that they showed us a human history in which Truth is always relative – contingent, determined by relations of power in the societies of the day. So it is with 'human nature' – always subject to the presiding order of the day. The notion of 'human progress' moreover is but a few centuries old, and already dated. Thus, today's human society cannot be regarded either as inevitable or as a pinnacle of either human, or indeed planetary, evolution. It is but what is here, now, today: the result of countless bifurcation points and phase transitions, where things could have gone one way or another. As Bergson put it, 'There has been no particular impulse towards social life; there is simply the general movement of life, which on divergent lines is creating forms ever new.'[18]

Even the work on social animals, such as that of E.O. Wilson, approaches this issue with foundationally mechanistic assumptions, suggesting that eusociality in ants, bees and humans has direct correlations. Wilson, perhaps, would be surprised to know that Bergson had made the analogy a century before. But for Bergson, the differences between the two categories of social animals are fundamental:

> We get this impression when we compare the societies of bees and ants, for instance, with human societies. The former are admirably ordered and united, but stereotyped; the latter are open to every sort of progress, but divided, and incessantly at strife with themselves. The ideal would be a society always in progress and always in equilibrium, but this ideal is perhaps unrealisable: the two characteristics that would feign complete each other, which do complete each other in their embryonic state, can no longer abide together when they grow stronger.[19]

In other words, for Bergson, the ants have achieved equilibrium and are going no further; humans remain on the move. Both in ecological complexity terms and in terms of the *élan vital,* this means a world of difference. Yet, for Wilson, it is clear that 'Within a generation, we likely will have progressed enough to explain the physical basis of consciousness.'[20] Personally, I doubt this. But as we saw in Chapter 2, in Bergson's understanding, over a century ago, it was already clear that the physical basis – the brain – was within the grasp of science, eventually. Yet such an understanding will only be on the mechanistic side of the Cartesian divide, and Huxley's epiphenomenalism will continue to offer the paradox: 'I am aware that I have no awareness,' even when the workings of the brain are all, finally, thoroughly understood. Neuroscience may indeed, then, be in a position to state clearly how all the various identifiable processes unfold, and which parts of the brain they activate and unfold in and through.[21] It will still have nothing to say about *who* is experiencing these processes, *who* has studied and observed and speaks about them, and how it all *endures*. The elephant will remain in the room.

Bergson's understanding of duration – of the *durée réelle* – and of the nature of the self and the irreversibility of time, are rooted in the experience of the self, in the experiencing subject, at the crest of the unfolding moment: it is *lived emergence*. This is not to come down on the side of the idealist in an argument between realism and idealism – Bergson deconstructs this false dichotomy; the collapse of the distinction between *inside* and *outside* already implies that our *lived emergence* is something which incorporates both what we understand as objective and the subjective by reimagining both as a united flow. Bergson's description of the continual expansion of the field of memory, from which we draw, and which makes this moment – and ourselves – at every moment unique, suggests that it is not only the unfolding physical reality of nature, but also our own conscious selves, that can be pictured in the terms of the 'shortest description' – too complex to be described in any way other than by living out our lives. We are the quintessential autonomous agents: our durational experience of the world is *lived emergence*, an irreducible shortest description of the real.

How our societies 'evolve' then – at a hierarchical level above and decoupled from our individualities, which become the buttons and threads of far greater social networks – cannot be determined by our biology, any more than our consciousness is determined by the functions of the brain. That our bodies and brains form the biological substratum is given; that this determines the content of our minds and our societies is not.[22]

Wilson asserts, we are 'an evolutionary chimera, living on intelligence steered by the demands of animal instinct. This is the reason we are mindlessly dismantling the biosphere and, with it, our own prospects for permanent existence.'[23] Yet we have persisted on this earth for millennia without doing such harm. To suggest that what is happening now – the so-called Great Acceleration[24] – must be read back into our history as a species, as Wilson does, is to continue to believe somehow in a story of progress, that we are here at the pinnacle of whatever story it is that our species has undertaken. This is a 19th century view. Surely the implications of the notion of emergence in complex adaptive systems, and of the *élan vital,* are that any species can take any route at any time, according to a range of conditions and eventualities so vast as to be impossible to imagine in the life of the universe. As Kauffman says, 'the biosphere as a whole may be collectively autocatalytic and – somewhat like the nuclear chain reaction – collectively supracritical, collectively catalysing the exploding diversity of organic molecules we see.'[25] In other words, the whole planet is indeed self-organising: not in the rather machinic understanding of closed self-regulating systems implied by Lovelock, but in the edge-of-chaos far-from-equilibrium dissipative structure sense explored by Kauffman and Goodwin and others. The story of the planet, as Botkin underlines in his tales of the constant changes in the biosphere that we see in the fossil record and the ice-core samples, does not have a 'natural' state – nor does it have any line of progress. As Bergson put it, both the mechanistic explanation and the finalistic explanation fail to take into account the facts as empirical science reveals them. There is neither stable dynamic order, nor progress. There is, instead, continual creativity, continual emergence, constant change.

There is no inevitability, in other words, to our current predicament, to the current human civilisation as we know it, and the ways in which its impact on the planet are rendering it, in a very short time span, potentially uninhabitable – at least by us. I would suggest, rather, that it is our current civilisation, the current episteme of (post)modernity, industrialisation, and the globalisation of industrialisation, that is at fault in destroying our habitat, and not some biodetermined Manichean flaw in 'human nature', as Wilson would suggest. Certain social forms seem, as Diamond elucidates, to push towards collapse, while others persist in better harmony with their environments. We seem to have one of the former in the ascendant across the globe in the present era, but there is no inevitability to this.[26] That the sources of morality, religion, science and the creative arts are fundamentally biological in nature – as Wilson asserts, quite contrary to his other more complex arguments – is to reduce them to equations on a piece of paper, in the manner of 1950s cybernetic automatons, making of them Laplacean outcomes of initial states, rather than unpredictable and emergent. That gathering in groups – with all the network dynamics that that entails – is both a blessing and a curse, as Wilson would have it, is to fall back upon religious symbolism as old as Janus to excuse the selfishness of those who in truth do not work well in groups, and seek only to control them for their own selfish ends. Indeed, that selfishness – lauded by Ayn Rand[27] – and the principles of the Scottish Enlightenment and Smith's paradox of the general good somehow emanating from each pursuing only their own, may in truth be closer to the villain of the piece, along with the Cartesian divide which shut out much of the morality which in the past had accrued to human existence. A new moral order that foregrounds collaboration, cooperation, and altruism over competition and struggle, would soon bring our current predicament to an end. *Homo faber,* with an appropriate organising principle, is more than capable of realigning global technology and resource use toward a far lighter footfall upon the biosphere that is our home: given the will.

Henry Gee is right when he rails against the more progress-oriented theories of Bronowski, and his ilk, of the so-called 'Ascent of Man'. Human beings are indeed, in a sense, an 'Accidental Species' – and an imperfect one at that.[28] But this does not obviate the notion, as expressed by Bergson, that consciousness – as the driving principle of life, as the currency and heart of the *élan vital* – has found its highest expression through humanity: at least on this planet, at this time. In Bergson's universe, where the mental is no longer divided utterly from the physical as it is in Descartes', where life acts upon inert matter as an expression of consciousness, where both inert matter and consciousness are fluid, multiple, and constantly on the move, the conscious human is like a window onto the wider consciousness of the universe: a stained glass window, it is true, filled with the imperfections of our biological heritage, the best that life could come up with, hampered as it is by the difficulties of animating the inert.

Here, indeed, is Bergson's answer to the notion of the individual soul: it is a piece of the universal consciousness on loan, as it were, returning, at the end of an individual life, to the wider universal pool of consciousness. As Bergson puts it, a true philosophy of the spirit should 'resolve to see the life of the body just where it really is, on the road that leads to the life of the spirit. But it will then no longer have to do with definite living beings. Life as a whole, from the initial impulsion that thrust it into the world, will appear as a wave which rises, and which is opposed by the descending movement of matter.'[29] It is humanity, in a poststructuralist decentring of the individual human, therefore, that is at the crest of the unfolding of evolution, rather than any individual. 'Thus souls are continually being created, which, nevertheless, in a certain sense pre-existed. They are nothing else than the little rills into which the great River of life divides itself, flowing through the body of humanity.'[30] For the self – the one in the many – is only so when viewed through the intellectual – analytic – lens that divides the whole. The 'many-ness' of that whole, indeed, only exists when it comes into contact with matter. 'I am then (we must adopt the language of the understanding, since only the understanding has language) a unity that is multiple and a multiplicity that is one.'[31]

For Bergson, the achievement of humanity is that consciousness has broken through matter to become, in a sense, self-aware. In a sense, though the Individual Subject, now decentred, can no longer act as guarantor between subject and object, humanity as a whole now becomes the guarantor between matter and spirit: that most privileged of images, our bodies, which we both perceive, and which perceive, in the milieu of our shared and social selfhood, grants duration to a universe that would otherwise take but an instant to run its course, brings narrative, choice, and the free action of creativity to that which was but inert.

Perhaps, with neural networks, something like a phase transition is involved: where, in the human brain, by dint of our sociality and our tool manufacture and use, enough complexity of conscious activity is underway that a qualitatively different kind of consciousness has arisen, setting us apart from others in the animal kingdom. It is not a physically, or quantitatively different consciousness to that of the rest of the animal kingdom, in whom consciousness arises through mobility, or to that of inert matter, which is conscious to the extent that in the present it remembers its immediate past; a nervous system is not a requirement for consciousness, as Bergson stressed more than once.[32] Human consciousness, however, at a decoupled hierarchical level above the rest, is different in *kind*:[33]

> With man, consciousness breaks the chain. In man, and in man alone, it sets itself free. The whole history of life until man has been that of the effort of consciousness to raise matter, and of the more or less complete overwhelming of consciousness by the matter which has fallen back on it.[34]

But Bergson is quite clear that this human exceptionalism is not a finalism of any kind, but an achievement over the automatism of instinct, a release from the constant focus upon maintaining the machine of the body – (we might say) a 'phase transition' beyond animal consciousness:

> Man not only maintains his machine, he succeeds in using it as he pleases. Doubtless he owes this to the superiority of his brain, which enables him to build an unlimited number of motor mechanisms,

> to oppose new habits to the old ones unceasingly, and, by dividing automatism against itself, to rule it. He owes it to his language, which furnishes consciousness with an immaterial body in which to incarnate itself and thus exempted from dwelling exclusively on material bodies, whose flocks would soon drag it along then finally swallow it up. He owes it to social life, which stores and preserves efforts as language stores thought, fixes thereby a mean level to which individuals must raise themselves at the outset, and by this initial stimulation prevents the average man from slumbering and drives the superior man to mount still higher....
>
> ...It is in this quite special sense that man is the 'term' and the 'end' of evolution. Life, as we have said, transcends finality as it transcends the other categories. It is essentially a current sent through matter, drawing from it what it can. There has not, therefore, properly speaking, been any project or plan. On the other hand, it is abundantly evident that the rest of nature is not for the sake of man: we struggled like the other species, we have struggled against other species....It would be wrong to regard humanity...as prefigured in the evolutionary movement. It cannot even be said to be the outcome of the whole of evolution, for evolution has been accomplished on several diverging lines, and while the human species is at the end of one of them, other lines have been followed with other species at their end.[35]

It is thus in the sense that we are the best yet, down one line of development, under the circumstances – not the best nor planned for – that Bergson can be described as a human exceptionalist; the best expression of the original impulse of life that it has been able yet to conjure, in its upward, self-organising emergence against the downward tide of entropy – at least on this planet.[36]

Quite contrary to Wilson's conception of the creative arts as a mere biological reflex rooted in an instinctive mating-ritual display, for Bergson, although he never directly focuses on the issue, art is all too often not the question, but the answer. Bergson's concentration upon novelty, upon indetermination, has inevitably piqued the interest of those concerned with aesthetics, and, as one commentator concludes: 'We would not admire the new if the old were completely satisfying. Indeed, as Bergson argues, the endless flow of life constantly creates new vital orders, but its currents carry new confusions and indeterminate elements as well. Art takes up the challenge or else it is vacuous.'[37] *Creative emergence*, then, remains creative in part because whatever is created – however fine or celebrated it may be – is never final, perfect, or complete, but always contingent, imperfect, pregnant with that which must follow: be it a work of art, music, architecture, science, technology, or, indeed, philosophy. The very creativity of the human, indeed, as a centre of action, becomes defining of our humanity, and our artistic endeavours, in some senses, our highest.

Bergson's philosophy, then, enjoins us to be creative, to become one with the ongoing flow of creativity that is the nature of the unfolding universe of which we are a part, and to recognise that we are neither the incredibly unlikely happenstance of an arid scientism, nor the realisation of some divine destiny. If, moreover, we are not an accident of randomness, nor the planned perfection of a pre-determined plan – and most definitely a 'we', rather than a collection of 'I's – we need neither hold to a dogma of individualist competition, nor to a collective duty to some divine maker. We may, on the contrary, understand that competition and struggle are corrective, adaptive forces shaping a universal impetus toward life, and that it is we, indeed, who are the makers: as Bergson says, our '*intelligence, considered in what seems to be its original feature, is the faculty of manufacturing artificial objects, especially tools to make tools, and of indefinitely varying the manufacture*.'[38] Our moral responsibility, then, is to life, and to each other, not just to our individual selves or to the idea of a planned and determined end. As Goodwin underlines, we are every bit 'as altruistic as we are selfish.'[39]

It is then, in this sense, that a new moral order in which we work, creatively, together, and not alone, for all our common good, rather than just our own, that we humans would better reflect the universe we live in, and the stuff of which we are made. The isolationist dogma of individualism, in other words, is the problem, and not, as Wilson would have it, some biological inevitability that makes us selfish. As a recent paper in the journal *Complex Systems,* that subjected several economic systems to complex computational modelling with zero-intelligence autonomous agents, put it, 'while it creates more welfare (utility and money) at the aggregate level, the competitive market distributes it much less equally.' In other words, although market capitalism may increase the total wealth say from $1trillion to $2trillion, it is soon found that $1tr belongs to five people, that another thousand people own $0.5tr, and that the remaining $0.5tr is spread unevenly amongst the millions of people that are left. 'The competitive market structure is responsible for an inequality amplifying effect: goods become concentrated in the hands of greedy consumers and money in the hands of skillful producers.'[40] The net effect is what Picketty[41] has recently shown – the creation of megarich elites and mass poverty that makes the whole system ultimately sufficiently top-heavy to likely bring it down, to no-one's benefit. (Though, under current technological circumstances, that fall cannot come too soon, if mass extinction and climate change are to be halted.)

Darwin, in short, may have borrowed from Adam Smith in foregrounding the individualist competition and struggle of natural selection as the only and sufficient mechanism of evolution, but Darwin was a man of his time. Bergson's evolutionism, coupled with its corollaries in quantum physics and ecological complexity, grants us a world where we indeed belong, a universe, as Kauffman puts it, where we are 'at home' – a universe whose consciousness, as Bergson puts it, we share, and in this kind of world, no man is an island, and life is a much more collaborative affair.

As in his philosophy, so in his political career, Bergson stressed the importance of openness versus closure in international relations. In *Two Sources of Morality and Religion,* in the first part, Bergson – the political philosopher – defined humanity as caught between the notion of societies, and of society; between that which is closed, and that which is open. At the helm of the ICIC he hoped to encourage openness, and through UNESCO and the UN that sense of the human species as one family and our unity being far more important than the rivalries between our different cliques is something all the more important as global problems such as climate change threaten everyone of us.

So what of the future?

Almost in the way of a coda to this volume, then, in the context of all I have said concerning creative emergence, it seems appropriate that I turn my thoughts toward the future, and hazard some few guesses at what may be in store.

Prediction, as it will have become very obvious in the course of this volume, is not something which I believe particularly easy to undertake! The strange and perplexing interface between that which is determined and that which is not, the power of our 'centres of action' that may begin chains of cause and effect whilst such choices themselves escape being merely the effect of a cause, depends upon an inherent unpredictability in such chains themselves: an indetermination, incorporating random chance in complex structures that our conscious selves may take advantage of, steer, and thereby, where the constraints of the possible allow, use to pursue our goals. The nature of such steering, moreover, in a poststructuralist understanding of the world, is inherently collective, contingent, contextualised; in a word, (at least) *largely* determined by our upbringing and the circumstances, ideological infrastructure and power relations around us. Whilst individuals appear at times to be able to undertake such steering, it is indeed whole populations perhaps to whom that steering ought ultimately to be ascribed, just as in the case of genealogy.

What is it, then, to steer, to pursue goals, to aim towards a desired future? What is it for an individual? What is it for a population? Is such a population that of a town, a city, a country, a region? Perhaps it is impossible to say, and only the eddies and currents within the whole human population of the world could be discussed in such terms. For individuals, like the rest of our lives, it is surely inevitable that there are many layers to such endeavour, that in our attempts to pursue individual goals deep patterns are at work as much as more conscious choices. Yet for some things, it seems, 'the time is ripe', and opportunities to pursue them seem to appear in the course of duration just as their pursuit becomes apposite. All the circumstances of years of preparation and unique, once-in-a-lifetime opportunities to at last flower in our chosen careers, or make a significant shift, all too often coincide with the death of a parent, their pride in our rise and our sorrow at their loss all mixed up with the intensity of the moment as we reach for our prize. Being aware of and grasping such opportunities seems the part our conscious selves may play. But how is it that such simultaneity of desire, release and opportunity can arise? I believe the answer is in the concept of narrative. In Bergson's *durée réelle* it is possible, I suggest, to find something not unlike the structuralist shared mythology described by Levi-Strauss, at work. I suggest this, because, although it is only my intuition, it strikes me that there is, within durational succession and simultaneity, a phenomenon that assists us in our sense-making, that one might call 'coincidence'.

Now, the word 'coincidence' is, already, laden with a meaning that discounts what I am suggesting. 'It's just coincidence', one says, dismissing any significance to the concurrence of two incidences. This very usage of the term belies an older, common usage imputing such very significance. One must surmise in circumstances of more pervasive religious practice, and perhaps even more so amongst the superstitious, that all manner of significance can be and has been imputed to any and every such coincidence, to the extent that *all* coincidence becomes tarnished with such over-interpretation. In superstitious times and places, such as medieval Europe, every such coincidence would have been interpreted as a 'sign' or 'portent' that some pre-determined, prophesised doom was about to unfold. Clearly, aligned with Bergson's attack upon the determinism of such finalism, it is not in this sense that I wish to discuss 'coincidence'. Yet those who saw such signs and portents, for all that they overlaid the coincidence with their own beliefs, their own stories, nonetheless witnessed, and experienced – at least in the more strange and shocking such cases – a phenomenon worthy of our interest.

It seems to me that a coincidence is something wherein the concurrence of incidences – such as a readiness and an opportunity – makes a narrative link that strikes a chord in our sense of who we are and who we are trying to be. Such narrative, no doubt, is cultural in origin, and that origin will likely differ from region to region, from historical context to historical context, and what might seem a coincidence to someone in fourth century China might, indeed, not even be noticed in 17th century New England. Tales of such coincidences will strike a chord for many in the right time and the right place. Yet for the person experiencing the immediate strangeness and shock of such a coincidence, the chord that is struck can often feel personal, something which has happened to *them*, been experienced by *them*. Perhaps it is merely that their own story – for that moment – mirrored precisely a cultural narrative that was unfolding. In such a way, in coincidence we might say that there is a durational and intuitive – and thereby, in Bergson's terminology – *empirical* evidence of the stories we make for ourselves, based upon the narratives of our cultural milieu. It is this *empirical* evidence for our stories that makes coincidence so shocking, set as it is amongst the otherwise more unpredictable creative emergence of life, and lends weight to our stories.

In fact, the inheritance of such stories, and their spread across regions over time, such as the Graeco-Roman origins of much modern Euro-American-Australasian and post-colonial culture around the world, or the Confucian core to the cultures of much of greater China, would suggest that vast areas of the modern world share similar such deeply ingrained and ancient cultural narratives against which coincidences might be mapped. Further, the structural similarities between such narratives would also make it possible, all too often, for us to recognise many kinds of coincidence across regions and historical contexts.

The most powerful cultural narrative of recent centuries has been that launched by the European Enlightenment. As the greatest power the world had known up until that time, China, turned inward, around 1500CE, so the small region known as Europe gained a chance to make an impact upon the world at large. Launched most successfully by that melting pot of European peoples and cultures, the British Isles, this

European narrative of innovation, individualism, and its attendant conquest, appropriation, and suppression, has had an unprecedented effect upon our own population and that of many of the species and habitats around us.

In 1650CE world population was just reaching half a billion.[42] By 1800 it was around 1bn. By 1900 it was over 1.5bn. By 1959 it was around 3bn. Today it is over 7bn and looks set to peak somewhere over 9bn by 2050. The growth rate seems to have peaked in the 1960s, wavered in the decades that followed, and now be tailing off. The reasons for this unprecedented growth are usually given as medical and agricultural advance preventing death from disease or hunger, coupled with the older strategy of a high birth rate to make up for infant mortality only slowly settling back to a lower birth rate as infant survival improves. Today the only places in the world where the rate of growth is still high are those where there remains poverty, war, famine and instability. Thus, the European narrative of innovation has brought about an immense change in our population, which has itself had an enormous impact upon the world around us.

In this modern world of massive population, and most recently of our high-performance computing, there is both sufficient mass and calculation power for a network analysis of the phenomenon of coincidence to become possible. One can imagine, perhaps, the nature of some kinds of coincidence as analogous to the ghost-like appearance of waves that are not there, in quantum experiments where one particle is sent to pass through a screen with two holes. On the other side of the screen its trajectory takes into account the waves from the other hole as if there had indeed been other particles fired at the same time. The narrative links in the unfolding of our lives can sometimes reveal just such impossible and counterintuitive synchronies.

It might – and this is just guesswork – transpire that the narratives that have best stood the test of time – been most often supported by such coincidence – and form the deep mythological structuralism Levi-Strauss sought to unearth, trace the contours of complex patterns in the durational succession of human lives. It is important to recall that this is not in any way biodetermined: the mind, although coupled with its biological substratum of the brain, is not determined by it. But the shared conscious sociality of what it is to be human, I argue, clusters around narratives that transcend individuals, and condition entire periods of history, and these narratives might be susceptible to complex network analysis, incorporating attractors, state cycles, and homeostasis around regional variations.

In the context of the European narrative of innovation and individualism: if, as I say, with Althusser and Foucault, we grant that much of our personalities are absorbed as we grow, and shaped as we individuate (learned from our ancestors, shared with our peers, passed to our descendants); and that the element of this collectiveness that we call our selves – that which we individuate towards – is, at best, a matter of taking care of the self,[43] at worst merely a selfish process of accumulation – but, in either case of telling a coherent narrative of ourselves to ourselves – then perhaps this contemporary process of individuation is itself an attempt to trace the contours of a unique pattern through duration, to leave a narrative mark uniquely our own. Where in the past, then, such coincidences seemed to us signs and portents of a narrative given to us by some divine or animistic force, in the new narrative, since the European Enlightenment, such coincidences seem to us the empirical evidence of our own unique stories as they unfold.

If this is so, then, in the unique historical conditions of such large populations, coupled with the ambition – with varying success across the world – to ensure sufficient political freedom for large numbers to pursue such a personal route of individuation, then an unprecedented number of new and unique narrative patterns of individuation are being traced, shared, passed on into the global wealth of structural collective narratives, and their associated power/knowledge matrices, in which we are born, live, and die.

The old cultural narratives, in short, for all their continued power, are being joined by, not only powerful and overarching, new cultural narratives, but also a host of individual variations, and the potential for completely new ones. This, in evolutionary complexity terms, would seem likely to presage some kind of phase transition: massive population growth accompanied by massive diversification. The modern creative arts, certainly, beyond their mythological and religious origins, over the past few hundred years, have been home to such new and exploratory narratives – underlining indeed the emergent creativity I have been describing. The modern sciences – the pursuit and fruits of the scientific method and all the innovation it entails – form a narrative: of novelty, progress, and emergence, as we have glimpsed in the history and genealogy of the sciences offered in the volume. The tales of individual lives, moreover, over the past centuries, have become all the more fascinating for their variety and innovation. Indeed, the tale of the modern world, from the European Enlightenment onward, is thus a new narrative we have been making up as we go along – in our arts and sciences and political economy, and in our selfhoods – that is itself dedicated to the pursuit of novelty. Individualism, in other words, were it to be corrected by a good deal more of the collaborative, need not necessarily be regarded as 'all bad'. The competition and struggle of natural selection, as both Bergson and Kaufmann assert, remains an important corrective of the more collective, primary force of evolution. I would posit, indeed, that under these conditions – particularly if such collaboration is engendered to balance the excesses of individualism – a new level of human complexity is possible. A new phase transition of consciousness could be around the corner.

Unlike some others, who see on the horizon an artificial intelligence 'singularity',[44] wherein our machines become conscious, I would hazard a guess that this is just a metaphor for something much greater: a qualitative shift in our collective conscious experience of what it is to be human, born of the sheer complexity of our massive population and the unprecedented proliferation of unique tracings of personal narratives through duration. Perhaps the artificial intelligence will come first. No doubt our manufacture – particularly of such connectivity as the Internet – will be some part of it. Our personhood may, indeed, become post-human, and there is arguably no way in which we could see, beforehand, just what that may be like.[45] Things certainly seem to be moving very speedily towards some denouement we cannot glimpse – some bifurcation the outcome of which we are powerless to see, let alone predict. The dangers, too, are very apparent, and if we are to survive it is imperative that we address them.

Born, indeed, of the extraordinary Cartesian divide – which gifted us a becomingless, inert matter at our beck and call – technological advance over recent centuries, and especially the last few decades, has made everything in our conscious world flow so very much faster, and the impact upon our environment is rapidly catching up. As Paul Virilio has stressed, taking Bergson's concentration upon time further than Bergson, into a consideration of the *acceleration* of modernity, *speed* is the defining aspect of our era, and the core quality of much of our technology.[46] This is not to say that technology is not a good thing: tools and their use, as we have seen, define our humanity, and technology is far too broad a category to be depicted as 'good' or 'bad': one might just as well say such a thing of air. Yet, be it the sharp intake of breath or the hurricane that flattens a city, both would be better for us, perhaps, at a slower pace.

Just as the population growth rate is slowing, finally, I believe we too need to slow down: to collaborate more, appreciate more fully all that *endures,* and cease to rush headlong, competing with one another at breakneck speed. Healthy competition is sporting, after all. There is nothing inevitable, or indeed healthy, about what we are doing now to our planet. In so many respects it is a society trashing its own home. Yes – we are capable of wrecking it, but we are also capable of choosing not to! Our survival, and the success of the shift that seems about to come, may depend upon just such a collective choice.

Notes

1. Mullarkey, J (1999) *Bergson and Philosophy* Notre Dame, IN: University of Notre Dame Press p. 5
2. Anand, M., Gonzalez, A., Guichard, F., Kolasa, J. Parrott, L. (2010) Ecological Systems as Complex Systems: Challenges for an Emerging Science *Diversity* 2, 395–410
3. Hooker, C (2011) 'Introduction to Philosophy of Complex Systems: B' in *Philosophy of Complex Systems* edited by Cliff Hooker, Oxford: Elsevier p. 841
4. Kauffman, S (1995) *At Home in the Universe* Oxford: OUP p. 17
5. Although Alfred North Whitehead and other 'process' philosophers have drawn near to it, and likely bear looking at more closely, this is not the task of this volume.
6. *CE* p. 117
7. Goodwin, B (1994) *How the Leopard Changed its Spots* New York: Charles Scribner & Sons p. 11
8. ibid. p. 13
9. Foster, J (2011) 'Economic Systems' in *Philosophy of Complex Systems* edited by Cliff Hooker, Oxford: Elsevier p. 509
10. Kauffman, S (1995) *At Home in the Universe* Oxford: OUP p. 15
11. ibid. p. 15
12. ibid. p. 33
13. ibid. p. 33
14. ibid. p. 48
15. *CE* p. 126
16. *CE* p. 271
17. Kauffman, S (1995) *At Home in the Universe* Oxford: OUP p. 51
18. *CE* p. 111
19. *CE* pp. 111–112
20. Wilson, E.O (2012) *The Social Conquest of Earth* London: Liveright p. 9
21. Though Susan Greenfield seems keener on an explanation that is more holistic, wherein a number of different areas of the brain are involved all at once with many of these processes, and trying to localise them to one part seems like trying to fit facts to theory, as we have seen in mid-20th century ecology.
22. For an exploration of the political implications of complexity theory see the final chapter in my collection of essays, Kreps, D (2015) *Gramsci and Foucault: A Reassessment* Farnham: Ashgate Publishing
23. Wilson, E.O (2012) *The Social Conquest of Earth* London: Liveright p. 13

24. Steffen, W., Broadgate, W., Deutsch, L., Gaffney, O. and Ludwig, C. (2015) The trajectory of the Anthropocene: The Great Acceleration *The Anthropocene Review* 1–18, published online 16/1/15 Also see Lewis, L. and Maslin, M (2015) Defining the Anthropocene *Nature* 519, p. 171–180
25. Kauffman, S (1995) *At Home in the Universe* Oxford: OUP p. 115
26. Diamond, J (2005) *Collapse: How Societies Choose to Fail or Succeed* London: Penguin
27. See Curtis, A. 2011. *All Watched Over By Machines of Loving Grace* London: BBC
28. Gee, H (2013) *The Accidental Species: Misunderstandings of Human Evolution* Chicago: University of Chicago Press.
29. *CE* p. 293
30. *CE* p. 294
31. *CE* p. 281
32. *CE* p. 122
33. *CE* p. 200
34. *CE* p. 288
35. *CE* pp. 288–289
36. Though it may be, as the Fermi paradox would suggest, that this planet is indeed the only one where such a break-through has taken place. If so, it could even be conceivable that the so-called ‘axis of evil’ placing the universe along the line of the ecliptic has more to it than meets the eye. It is equally possible that – as one group of researchers recently suggested (http://www.fhi.ox.ac.uk), the most likely solution of the Fermi paradox is that intelligent species never survive long enough to spread beyond their own planet.
37. Lorand, R (1999) Bergson’s Concept Of Art *British Journal of Aesthetics*, 39(4)
38. *CE* p. 153
39. Goodwin, B (1994) *How the Leopard Changed its Spots* New York: Charles Scribner & Sons p. 13
40. Bersini, H and Zeebroeck, N (2012) Why Should an Economy Be Competitive, *Complex Systems* 21:35
41. Picketty, T & Goldhammer, A. (2014) *Capital in the 21st Century* London: Harvard University Press
42. Figures from the US Census Bureau http://www.census.gov/population/international/data/worldpop/table_history.php
43. Foucault, M (1988) *Technologies of the Self* Massachusetts: University of Massachusetts Press
44. Kurzweil, R (2006) *The Singularity is Near: When Humans Transcend Biology* London: Penguin
45. Roden, D (2014) *Posthuman Life: Philosophy at the Edge of the Human* London: Routledge
46. Virilio, P (1986[1977]) *Speed and Politics: An Essay on Dromology.* New York: Semiotext(e)

Glossary

A few of the environmental biology terms used in the book:

Biomes the major ecosystems: for example, tropical rain forests, coral reefs, grassland

Cladistics a taxonomic system grouping species by common ancestry

Ecosystems ecological communities of species and their environments

Expression the fine tuning of genetic inheritance, presenting a far more complex picture than the gene-per-trait dream of the late 20th century

Fitness how selected variations in a species match the conditions of the environment

Functionalism evolutionary theory that considers external or adaptationist drivers as primary

Gradualism variations and mutations take place in very small steps, very slowly

Macroevolution broad-scale changes as observed by palaeontologists

Microevolution changes seen in local populations

Modern synthesis incidentally the title of a book by Julian Huxley in 1942, but most commonly the settled view of the majority of evolutionary theorists since the middle of the 20th century, centred around: gradualism, natural selection, and Mendelian genetics

Natural selection organisms whose offspring are advantaged against others will, on average, be those variants that are fortuitously better adapted to their environments

Niche how the environment itself is shaped by species living within it

Ontogeny developmental life cycle of the organism

Phylogeny development, descent and branching of species

Saltation the notion of sudden change from one generation to the next

Speciation development of new species

Structuralism evolutionary theory that considers internal or formal drivers as primary

Taxonomy a standardised naming system for animal and plant species

Unit of selection either the gene, the organism, the species, or a hierarchical mixture of all three

Variation the range of traits and features attributed to a species

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