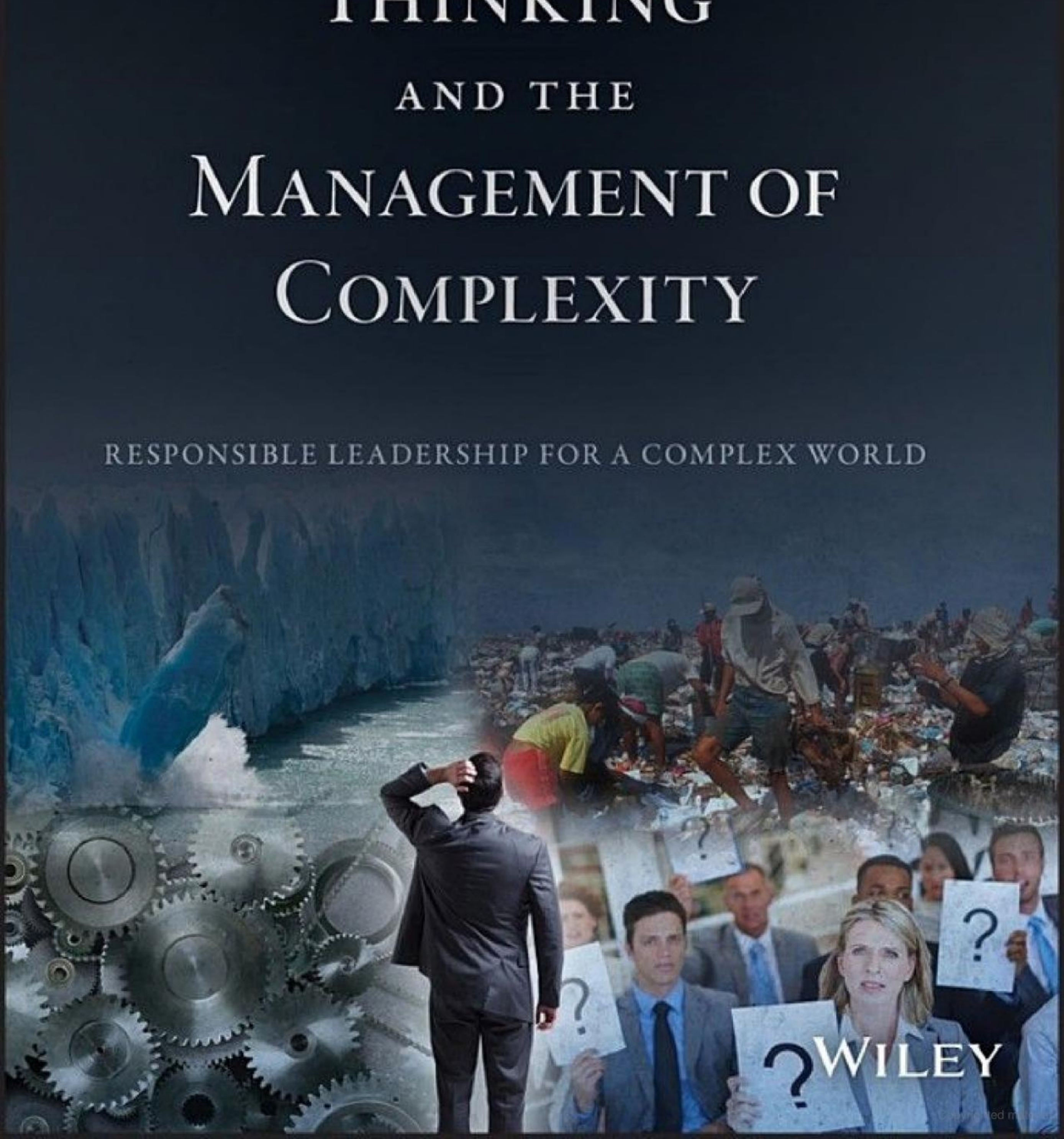
MICHAEL C. JACKSON

CRITICAL SYSTEMS THINKING AND THE MANAGEMENT OF COMPLEXITY

RESPONSIBLE LEADERSHIP FOR A COMPLEX WORLD



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Michael C. Jackson

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This edition first published 2019

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John Wiley & Sons Ltd, The Atrium, Southern Gate, Chichester, West Sussex, PO19 8SQ, UK

Editorial Office

9600 Garsington Road, Oxford, OX4 2DQ, UK

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Library of Congress Cataloging in Publication Data applied for

ISBN: 9781119118374

Cover design by Wiley

Cover image: © laflor/Getty Images-group of people, © John Lund/Getty Images-medal gears, © DNY59/Getty Images-man looking at wall, © Brasil2/Getty Images-landfill, © DurkTalsma/Getty Images-iceberg

Dedication

To Pauline, Christopher and Richard:

This book is what I think. It is not all I know.

That, I hope, I have conveyed to you in other ways.

Dust as we are, the immortal spirit grows
Like harmony in music; there is a dark
Inscrutable workmanship that reconciles
Discordant elements, makes them cling together
In one society.

Wordsworth (*The Prelude*, 1850)

Preface

There is a considerable debate about how to describe the modern world. Alternatives include the following: a global village, postindustrial society, consumer society, media society, network society, risk society, late capitalism, high modernity, postmodernity, liquid modernity, and the information age. To some, the new names just signal the rapid acceleration of changes in society that started to emerge between the sixteenth and eighteenth centuries. To others, we have crossed a threshold and entered a completely new era. What no one doubts is that things have become much more complex. We are entangled in complexity.

An IBM survey of more than 1500 Chief Executive Officers worldwide states:

> The world's private and public sector leaders believe that a rapid escalation of 'complexity' is the biggest challenge confronting them. They expect it to continue – indeed, to accelerate – in the coming years.
>
> (2010)

An OECD report begins:

> Complexity is a core feature of most policy issues today; their components are interrelated in multiple, hard-to-define ways. Yet governments are ill-equipped to deal with complex problems.
>
> (2017)

At the global level, economic, social, technological, and ecological systems have become interconnected in unprecedented ways, and the consequences are immense. We face a growing set of apparently intractable problems, including the nuclear threat; continual warfare; terrorism; climate change; difficulties in securing energy, food, and water supplies; pollution; environmental degradation; species extinction; automation; inequality; poverty; and exclusion. Attempts to provide solutions to these ills only seem to make matters worse. Unpredictable "black swan" events (Taleb 2007), like the fall of the Soviet Union, 9/11, and the financial crisis, have become frequent and have widespread impact. On top of this, there are fewer shared values that help tame complexity by guaranteeing consensus. At the more local level, leaders and managers, whether operating in the private, public, or voluntary sectors, are plagued by interconnectivity and volatility and are uncertain about how to act. They have to ensure that objectives are met and that processes are efficient. They also have to struggle with complex new technologies and constantly innovate to keep ahead of the competition and/or do more with less. They have to deal with increased risk. Talented employees have to be attracted, retained, and inspired, and the enterprise's stock of knowledge captured and distributed so that it can learn faster than its rivals. This requires transformational leadership and the putting in place of flexible, networked structures. Changes in the law and in social expectations require managers to respond positively to different stakeholder demands and to monitor the impact of their organization's activities. They have to manage diversity and act with integrity.

Various authors have sought to summarize what they see as the key features of the complex world in which we live. Boulton et al. (2015, p. 36) provide some valuable generalizations, seeing it as:

- *Systemic and synergistic*: interconnected and resulting from many causes that interact together in complex ways
- *Multiscalar*: with interactions across many levels
- Having variety, diversity, variation, and fluctuations that can give rise to both resilience and adaptability
- *Path dependent*: contingent on the local context, and on the sequence of what happens
- *Changing episodically*: sometimes demonstrating resilience, at other times "tipping" into new regimes
- *Possessing more than one future*: the future is unknowable
- Capable of self-organizing and self-regulating and, in some circumstances, giving rise to novel, emergent features

Warfield (2002) sets out 20 "laws of complexity," emphasizing that 70% of these result from the nature of human beings. For him, it is our cognitive limitations, dysfunctional group and organizational behavior, differences of perception ("spreadthink"), and the conflict we engage in that have to be overcome if we are to get to grips with complexity.

Whether complexity arises from systems or from people, decision-makers are finding that the problems they face rarely present themselves individually as, for example, production, marketing, human resource, or finance problems. They come intertwined as sets of problems that are better described as "messes" (Ackoff 1999a). Once they are examined, they expand to involve more and more issues and stakeholders. Rittel and Webber (1981) call them "wicked problems" and argue that they possess these characteristics:

- Difficult to formulate
- It is never clear when a solution has been reached
- They don't have true or false solutions, only good or bad according to the perspective taken
- A solution will have long drawn out consequences that need to be taken into account in evaluating it
- An attempted solution will change a wicked problem so it is difficult to learn from trial and error
- There will always be untried solutions that might have been better
- All wicked problems are essentially unique; there are no classes of

wicked problems to which similar solutions can be applied

- They have multiple, interdependent causes
- There are lots of explanations for any wicked problem depending on point of view
- Solutions have consequences for which the decision-makers have responsibility

Summarizing, they describe the difficulties "wicked problems" cause decision-makers as follows:

> The planner who works with open systems is caught up in the ambiguity of their causal webs. Moreover, his would-be solutions are confounded by a still further set of dilemmas posed by the growing pluralism of the contemporary publics, whose valuations of his proposals are judged against an array of different and contradicting scales.
>
> (Rittel and Webber 1981, p. 99)

What help can decision-makers expect when tackling the "messes" and "wicked problems" that proliferate in this age of complexity? They are usually brought up on classical management theory that emphasizes the need to forecast, plan, organize, lead, and control. This approach relies on there being a predictable future environment in which it is possible to set goals that remain relevant into the foreseeable future; on enough stability to ensure that tasks arranged in a fixed hierarchy continue to deliver efficiency and effectiveness; on a passive and unified workforce; and on a capacity to take control action on the basis of clear measures of success. These assumptions do not hold in the modern world, and classical management theory provides the wrong prescriptions. This is widely recognized and has led to numerous alternative solutions being offered to business managers and other leaders, for example, lean, six sigma, business analytics, value chain analysis, total quality management, learning organizations, process reengineering, knowledge management, balanced scorecard, outsourcing, and enterprise architecture. Occasionally, they hit the mark or at least shake things up. It is sometimes better to do anything rather than nothing. Usually, however, they fail to bring the promised benefits and can even make things worse. They are simple, "quick-fix" solutions that flounder in the face of interconnectedness, volatility, and uncertainty. They pander to the notion that there is one best solution in all circumstances and seek to reduce complex problems to the particular issues they can deal with. They concentrate on parts of the problem situation rather than on the whole, missing the crucial interactions between the parts. They fail to recognize that optimizing the performance of one part may have consequences elsewhere that are damaging for the whole. They often fail to consider an organization's interactions with its rapidly changing environment. Finally, they don't acknowledge the importance of multiple viewpoints and internal politics. Fundamentally, and in the terms used in this book, they are not systemic enough. In the absence of more thoroughly researched ways forward, however, managers are left to persevere with their favorite panacea in the face of ever diminishing returns or to turn to whatever new fad has hit the market.

This book proposes systems thinking as the only appropriate response to complexity. In systems thinking, the study of wholes, and their emergent properties, is put on an equal footing with the study of parts. The approach also insists that a wide variety of stakeholder perspectives is considered when engaging with problem situations. It has a long history, but it is only recently that it has become possible to recommend systems thinking to leaders and managers as the cornerstone of their practice. This is because the philosophy and theory have now been translated into useful and usable guidelines for action. It possesses a range of methodologies that can be used to confront different aspects of complexity according to the circumstances. In its most advanced form, the systems approach encourages the employment of a variety of methodologies in combination to manage "messes" and "wicked problems." Critical systems practice informs this way of working and demonstrates how decision-makers can achieve successful outcomes by becoming "multimethodological."

The genesis of the book goes back to the early 1980s when Paul Keys and I, at the University of Hull, established a research program to inquire into the theoretical coherence and practical value of different systems approaches to management. One outcome was a much cited paper (Jackson and Keys 1984), which outlined a "system of systems methodologies." The research continued in the late 1980s and I wrote *Systems Methodology for the Management Sciences* (1991a), which provided an overview and evaluation of various strands of systems thinking and sought to provide a theoretical justification for critical systems thinking and the meta-methodology of "Total Systems Intervention" (TSI). In the same year, Bob Flood and I published a popularizing text, called *Creative Problem Solving: Total Systems Intervention*, which was the first practical guide to using different systems approaches in combination. *Creative Problem Solving* did well. However, in some important respects, it was flawed. Having completed another major theoretical tome in 2000 – *Systems Approaches to Management* – I became confident that I had done enough additional research to generate new thinking about the difficult issues surrounding the combined use of systems methodologies to ensure successful interventions. Again, I wanted to make the results of the work available in a more popular format. The outcome was *Systems Thinking: Creative Holism for Managers* (2003), which provided a richer array of background material, a more thorough analysis of the various systems methodologies and their strengths and weaknesses, and new material advocating a creative way of using systems approaches in combination. Fortunately, the book found a ready audience and was widely read and used by managers, researchers, and students. It has been translated into Chinese, Japanese, Russian, and Spanish. I promised, in its preface, that it would be my last book.

Times change and I decided to completely update and rewrite *Systems Thinking: Creative Holism for Managers*. My reasons are threefold. First, a lot of excellent research has been undertaken in the field since 2003 and I wanted to acknowledge and take account of that in developing my own conclusions. Much of the research relates to specific areas of systems thinking, and I will make reference to these contributions in the relevant chapters. Suffice it to say, at this point, that the research communities around complexity theory, system dynamics, organizational cybernetics, soft systems methodology, and critical systems thinking have been particularly active. Of the texts covering the wider field, I need to mention a few. From the Open University, that long-time bastion of systems thinking, have come Reynolds and Holwell, eds, *Systems Approaches to Managing Change: A Practical Guide* (2010), and Ramage and Shipp *Systems Thinkers* (2009). They are both very good. The former has an introduction to the various systems approaches and covers five methodologies in chapters written by their originators and/or advocates. The latter provides brief summaries of the work of 30 leading systems thinkers and an extract from the work of each. We are all grateful to Gerald Midgley (2002) for his four volumes of collected papers on "Systems Thinking." Comprehensive and well-edited, I have benefited from their existence throughout the writing of this book. Stowell and Welch (2012) cover the ground but with something of a bias toward soft systems thinking. Of the more specialized texts, Capra and Luisi's *The Systems View of Life: A Unifying Vision* (2014) provides an excellent overview of systems thinking in the physical and life sciences. It was a constant companion for most of my time writing the book although, I hope, I was eventually able to add to its conclusions by paying more attention to the social sciences. As will become obvious, my thinking, since 2003, has been influenced by a more careful reading of Luhmann (e.g. 2013). The volume I enjoyed reading most, in preparing the book, was Pickering's *The Cybernetic Brain*: *Sketches of Another Future* (2010), covering "British cybernetics" in the 1960s. I guess that is because I am a child of that decade when, in MacDonald's words: "The Beatles *felt* their way through life, acting or expressing first, thinking, if at all, only later" (2008, p. 22). It was not only the Beatles.

Second, as my thinking developed, I came up with new ways of explaining the material and a different understanding of what is useful to decision-makers and what is not. This altered my perception of the best way to structure the book and what to include. There is more upfront on basic philosophy as I have come to recognize the significance, for example, of Kant in orientating the systems worldview. I appreciate the value of complexity theory as a description of the world, and regard it as complementing and enriching the earlier systems view. On the other hand, complexity theory has failed to come up with anything resembling a practical methodology to address the issues it identifies. I do not, therefore, include a chapter on complexity theory in the "systems practice" section. In terms of the individual methodologies that are included, I have found space for chapters on "The Vanguard Method" and "Socio-Technical Systems Thinking." The Vanguard Method earns its place because of the popularity it has attained, especially in local government. The Socio-Technical approach played an important role in the early days of applied systems thinking and could have been included in the previous book. It shouldn't have fallen out of favor. I have dropped the chapter on "Postmodern Systems Thinking." In the crude terms of the previous book, I now see it as a retreat from the problems posed by complex-coercive situations rather than as an attempt to do something about them. I continue to employ ideas from postmodernism when it seems helpful. There are 10 individual systems approaches covered. They are, I think, the ones that are the most philosophically sound and thoroughly researched, and which have a good track record of application. Of course, there is a lot of subjectivity in this choice. I made a determined effort to "inhabit" and believe in each of the 10 methodologies during the weeks I was writing about it. I tried to become a Vanguard Method person, a system dynamics advocate, a soft systems thinker, and so on, for that period. It is up to the reader to decide whether I succeeded. Finally, there is more on "Critical Systems Thinking." There is a separate chapter on critical systems theory and its use in other management subdisciplines; a chapter on the variety of multimethodological approaches; and a chapter on my own latest thinking on "Critical Systems Practice."

The third reason for doing a new book is personal. In 2011, I was diagnosed with neuroendocrine cancer. This is incurable, once it has spread, but it usually gives you some time. Steve Jobs died of the disease the same year I was diagnosed. As a fellow sufferer, Alan Rodger, quipped: "Of all the things for me to have in common with the multi-billionaire, world-renowned genius, it had to be his illness." I was lucky that they could operate and I had most of my insides removed. Until recently, I did not think I would survive long and writing a book seemed low on the list of priorities (give me Hull Kingston Rovers, Hull City, and Yorkshire cricket for entertainment any day!). However by 2017, and despite another operation for a recurrence, it seemed I might still have a few years left. I just started writing. I hope you enjoy *Critical Systems Thinking and the Management of Complexity*.

Three apologies before I pass on to some acknowledgments. First, John Pourdehnad counseled me against using the phrase "the management of complexity" in the title. In his view, we need to "navigate" through complexity; we can't manage it. This is a good point and one with which I largely agree. However, I decided to keep the title as it is. There are some aspects of complexity that we can "manage"; the book is primarily for managers, broadly defined; and managing can carry the meaning of "handling," "coping," and "getting by," as well as controlling. Second apology: in a book covering this much ground I was driven, necessarily, to make use of a lot of secondary sources. I can claim to have read most of the original material at some time in my career, and only hope that has helped me to choose my secondary sources well. Third, the way the material is arranged in the book emphasizes some of the connections between authors and ideas and puts others into the shade. I have thought this through carefully and done the best I can to highlight the most significant linkages. I apologize for not doing better. There is a lot of work still to do.

I am grateful to the following for their permission to reproduce previously published material: Random House for Figure 7.1; Vanguard Press for Figure 10.1; SNCSC for Figure 10.2 and Table 18.1; Productivity Press for Figure 11.4; Plenum Press for Figure 16.6; and Elsevier for Figure 16.7.

I have been lucky to make and retain friends from school, from the universities I attended and the places where I have worked. They will know who they are because they will receive a signed copy of this book – whether they like it or not! I am grateful to them. Thanks to those who helped me in my systems career, especially Peter Checkland and the late Russ Ackoff, and to others with whom I have worked closely in developing systems ideas, particularly Paul Keys, Bob Flood, Ramses Fuenmayor, Amanda Gregory, Angela Espinosa, and Gerald Midgley. My thinking has also benefitted significantly from exchanges with various “sparring partners” for whose work I have the greatest respect – John Mingers, Werner Ulrich, Richard Ormerod, and Ralph Stacey. I have been influenced by the work of Jonathan Rosenhead and Colin Eden from the “Soft-OR” community. I am grateful to the many staff, acknowledged in Chapter 19, who worked with me in the Centre for Systems Studies. I was lucky to tutor some excellent masters' students. The contributions of Said Medjedoub, Joseph Ho, Mary Ashton, Ellis Chung, Steve Green, and Raj Chowdhury are referred to in the book. The work of many of my PhD students is acknowledged in the text and all of them contributed to the thinking: Mo Salah, E.A. Youssef, D.P. Dash, Giles Hindle, Nasser Jabari, Martin Hall, Alejandro Ochoa-Arias, Bridget Mears-Young, Amanda Gregory, Luisa Garcia, Andres Mejia, Alvaro Carrizosa, Maria Ortegon, Beatriz Acevedo, Clemencia Morales, Roberto Palacios, Catherine Gaskell, Gokhan Torlak, and Luis Sambo. Thanks to those who helped me to establish and make a success of Hull University Business School between 1999 and 2011. It was a huge endeavor, a fantastic learning experience, and great fun. Bill Walsh was an excellent chair of its Advisory Board for many years. Thanks to Dr. Andrew Chen who has generously established an annual lecture in my name at Hull. Special acknowledgment is due to my surgeon at St James Hospital, Leeds, Professor Peter Lodge, whose knowledge and skills have ensured I am still here. The members of the “Old Gits' Club” have never been completely convinced by systems thinking and keep my feet on the ground. Nevertheless, one of them, David Tucker, helped me to improve the manuscript. As ever, I owe so much to my immediate family. The book, as with all the best things in my life, would not have been possible without the unwavering support of my wife Pauline. It is dedicated to her and my two sons Christopher and Richard. I can also announce that, with the birth of Freddie to Christopher and Tess, the next generation of Jacksons has started to arrive. Kelly passed away, so Molly is now the dog enjoying the walks on Beverley Westwood. I have enjoyed the process of thinking through and writing the book in Beverley; the North Yorkshire Moors; and Blanca, Spain. But it is definitely my last book.

Beverley, 2 October 2018

Michael C. Jackson

Introduction

The book is divided into four parts.

Part I considers the development and impact of systems ideas in four broad disciplinary areas: Philosophy (Chapter 1), the physical sciences (Chapter 2), the life sciences (Chapter 3), and the social sciences (Chapter 4). This theoretical background is necessary because it provides an introduction to the language of systems thinking and to the key concepts it employs. In the case of the social sciences, for example, a number of the systems thinkers studied in Parts II–IV have either developed their systems approaches with the help of social theory or, at least, related their work to social theory. This is significant because it can provide a basis for critique. The strengths and weaknesses of the different systems methodologies are related to the particular social theories they endorse. The intention in Part I is to make the absorption of the philosophical material as painless as possible for the reader and only to introduce those aspects of theory essential for understanding the practical systems approaches that are covered later.

Part II considers the development of systems thinking as a separate transdiscipline. Transdisciplines are unconstrained by normal academic boundaries and can recognize "messes" and "wicked problems" and not just, for example, individual marketing, production, human resource, and finance problems. Chapters 5 and 6 outline the emergence and significance of general systems theory and cybernetics, the two intellectual pillars on which systems thinking rose to prominence in the mid-twentieth century. Chapter 7 covers complexity theory, another transdiscipline that has come to the fore more recently. Complexity theory offers a complementary approach to systems thinking, adding to its theoretical armory and providing some new concepts that are appropriate for describing contemporary organizations and society.

Part III of the book turns to systems practice and the way systems ideas can be put to use in dealing with the problems posed by complexity. It begins by providing, in Chapter 8, an overview of applied systems thinking in the form of an updated "system of systems methodologies" (SOSM). Following this orientation, Part III is divided into sections, emphasizing that different types of systems approach have different visions of where the main sources of complexity arise. This broad division offers a starting point for discussion. There are six sections:

- Systems approaches for technical complexity (Type A)
- Systems approaches for process complexity (Type B)
- Systems approaches for structural complexity (Type C)
- Systems approaches for organizational complexity (Type D)
- Systems approaches for people complexity (Type E)

- Systems approaches for coercive complexity (Type F)

Using these headings for guidance, we consider (Chapters 9–18) 10 of the most significant attempts that have been made to construct a systems approach capable of improving the practice of management. The 10 methodologies outlined make use of the systems theory and concepts presented in Parts I and II. The manner in which they use systems ideas and the range of concepts employed are however different – in particular, in terms of what they regard as the most important aspects of the manager's task. There will be howls of anger that the different systems approaches are being "pigeon-holed." But we have to start somewhere. I will be absolutely clear about my starting point. The individual chapters will detail how the different approaches diverge from the broad distinctions initially employed and how some have evolved in an attempt to tackle other aspects of complexity. Each of the 10 approaches is presented in terms of its history, philosophy, and theory, methodology and methods, and examples of application are provided. The theoretical considerations set out earlier in the book are used to provide a critique of each approach.

One conclusion from Part III is that the different systems approaches emphasize and seek to address different aspects of complexity. Another is that they are heavily influenced by different philosophies and social theories and their particular strengths and weaknesses stem in part from the theoretical assumptions they take as their starting point. It follows that we have the best chance of managing complexity overall if we can understand and capitalize on their different strengths and compensate for their different weaknesses by using them in combination. This way of looking at things is called critical systems thinking and is the focus of Part IV of the book. Critical systems thinkers argue that the different systems methodologies and methods must be employed together, creatively and in a theoretically informed way, to improve leadership and managerial and organizational performance. Part IV has three chapters. Chapter 19 looks at the theory that underpins critical systems thinking and its relevance for the management sciences generally. Chapter 20 considers some different ways that have been developed for using systems approaches in combination. My own latest version of "Critical Systems Practice" is set out in Chapter 21.

The book ends with a short conclusion.

In this introduction, I have sought to make clear the structure of the book and the logic underlying that structure. This is summarized in Table 1.

Table 1 The structure of the book.

Introduction		
Part I: Systems Thinking in the Disciplines		Chapter 1: Philosophy
		Chapter 2: The Physical Sciences and the Scientific Method
		Chapter 3: The Life Sciences
		Chapter 4: The Social Sciences
Part II: The Systems Sciences		Chapter 5: General Systems Theory
		Chapter 6: Cybernetics
		Chapter 7: Complexity Theory
Part III: Systems Practice		Chapter 8: A System of Systems Methodologies
	Type A: Systems Approaches for Technical Complexity	Chapter 9: Operational Research, Systems Analysis, Systems Engineering (Hard Systems Thinking)
	Type B: Systems Approaches for Process Complexity	Chapter 10: The Vanguard Method
	Type C: Systems Approaches for Structural Complexity	Chapter 11: System Dynamics
	Type D: Systems Approaches for Organizational Complexity	Chapter 12: Socio-Technical Systems Thinking
		Chapter 13: Organizational Cybernetics and the Viable System Model
	Type E: Systems Approaches for People Complexity	Chapter 14: Strategic Assumption Surfacing and Testing
		Chapter 15: Interactive Planning
		Chapter 16: Soft Systems Methodology
	Type F: Systems Approaches for Coercive Complexity	Chapter 17: Team Syntegrity
		Chapter 18: Critical Systems Heuristics
Part IV: Critical Systems Thinking		Chapter 19: Critical Systems Theory
		Chapter 20: Critical Systems Thinking and Multimethodology
		Chapter 21: Critical Systems Practice
Conclusion		

Part I

Systems Thinking in the Disciplines

> Mark this well, you proud men of action: You are nothing but the unwitting agents of the men of thought who often, in quiet self-effacement, mark out most exactly all your doings in advance
>
> (Heine 1834)

Part I traces the emergence of systems thinking in philosophy, the physical sciences, the life sciences, and the social sciences. The reason for concentrating on these broad fields of knowledge is that it demonstrates the necessity of systems thinking for making intellectual progress in a wider context than that of individual disciplines. A downside is that individual disciplines impacted by systems thinking, such as geography and political science, are ignored if not central to that purpose. Chapter 1 is a review of the long engagement that has taken place between philosophy and systems thinking. Chapter 2 looks at the physical sciences, the refinement of the "scientific method," and at how that method (based on "reductionism") enabled spectacular progress to be made in science and technology in the seventeenth, eighteenth, and nineteenth centuries. It notes, however, that newer discoveries in general relativity, quantum mechanics, and chaos theory are leading to a rethink of the traditional scientific method and requiring the physical sciences to embrace systems ideas. In contrast to the physical sciences, the life sciences, specifically biology and ecology, seemed to require a commitment to systemic thinking from their early days. As a result, they have provided a rich resource of systems concepts and played a major part in establishing systems thinking as a "trans-discipline." This is the topic of Chapter 3. In Chapter 4, the focus is on social theory, a field that makes significant use of systems ideas developed elsewhere but has also come up with its own original contributions to the systems approach. The treatment of theoretical matters in Part I is designed to illuminate and guide the practical employment of the systems methodologies that are detailed in Part III.

1
Philosophy

In the case of all things which have several parts and in which the totality is not, as it were, a mere heap, but the whole is something beside the parts ...

(Aristotle n.d., 350 BCE, VIII: line 1)

1.1 Introduction

Fritjof Capra (1975) has, for some time, been pointing to similarities between the holistic understanding of the world supplied by Eastern philosophy and the findings of modern science. Churchman regarded the *I Ching,* with its emphasis on dynamic changes of relationship between interconnected elements, as presenting the oldest systems approach (Hammond 2003, p. 13). Boulton et al. (2015) claim Daoism, with its sense of interconnection and co-creation, as a precursor of complexity theory. This book will restrict itself to the Western intellectual tradition. It is upon Western sources that systems practitioners have, probably to their detriment, almost exclusively drawn. As with so much in this tradition, we owe the first attempts to use systems ideas to the ancient Greeks. von Bertalanffy (1971) and Prigogine (1997) cite the pre-Socratic philosopher Heraclitus as an influence. More specifically, Aristotle (n.d.) 350 BCE was the first to imply that "the whole is more than the sum of its parts." Indeed, he reasoned, the parts only obtain their meaning in terms of the purpose of the whole. The parts of the body make sense because of the way they function to support the organism. Individuals can only find meaning in helping the state to achieve its purpose. The other great master in the Greek philosophical tradition, Plato, also found value in employing systems ideas across different domains. There is a Greek word *kybernetes* meaning the art of steersmanship. The word referred principally to the control of a vessel, but Plato (1999, pp. 230–231) used it to draw comparisons with steering the ship of state. Both uses imply regulation, which is why the name cybernetics was given to the new science of "communication and control" in the 1940s.

1.2 Kant

Moving forward two millennia, to the latter part of the eighteenth century, we reach Immanuel Kant. Kant is often seen as the greatest philosopher of the modern era and provided the Enlightenment with its motto: *Sapere aude!* (Dare to know!). Knowledge should be based solely on reason rather than superstition and tradition. Kant's work is significant for systems thinking for three reasons. First, he thought that science could obtain true knowledge, as it had with Newtonian physics, and he wanted to show why this was the case. He also wanted to understand the limitations of science. The second reason lies in his interest in "organicism" as a complementary approach to mechanistic thinking, especially in the study of nature. Third are his arguments about the capacity of humans to generate principles of moral conduct because, uniquely, they possess "the autonomy of the will."

In his *Critique of Pure Reason*, Kant sought to expose the shortcomings of both "rationalism" and "empiricism" as approaches to gaining knowledge. Rationalists, such as Descartes, believe that it is possible to employ cogent thinking alone to arrive at knowledge about the nature of things. In Kant's view using rational thought on its own leads to contradictions, for example, to proofs that God exists and doesn't exist. Reason has to be grounded in experience if it is to yield true knowledge. Empiricists (e.g. Locke, Berkeley, and Hume) believe that all knowledge has to be derived directly from experience through the senses. Kant thought that this was too subjective and opened the door to skepticism because our senses can easily deceive us. We need something more certain to rely on. Kant used the famous phrase: "Thoughts without content are empty, intuitions [perceptions] without concepts are blind" (quoted in Kemp 1968, p. 16).

If we are to overcome the weaknesses of rationalism and empiricism, we require, Kant says, a revolution in philosophy akin to that of Copernicus in cosmology (Kemp 1968). Instead of seeing knowledge as dependent upon our minds representing what actually exists in reality, we should see it as based upon what we perceive conforming to the nature of the mind. It is because all human minds structure the experiences they receive in a particular way that shared perceptions and knowledge are possible. This notion of mind as the creator of reality becomes clearer if we consider the latest brain research. According to Armson:

> My senses receive 400 thousand million bits of data every second. My brain only deals with 2000 bits per second so I only notice a very small fraction – a half a millionth of one percent – of what I see, hear and smell. More extraordinary still is the observation that the 100 bits per second that trigger my visual perception are not enough to form any image of what is going on around me. My brain fills in the deficiency. It is hard to defend any claim to an objective view under such circumstances.
>
> (Armson 2011, loc. 975)

The world does not present itself to us as already organized. The mind must play an active role for humans to experience it as they do.

In pursuing this argument, Kant requires a distinction between "phenomena," things as they appear to our senses, and "noumena," things as they actually are in themselves. Knowledge is possible because there is an inevitable correspondence between our minds and things as they appear to us. This arises because our minds structure the sense impressions we receive in order that we can perceive them in the first place. Far from the mind being a *tabula rasa* (blank slate) upon which reality writes its script, it actually provides the framework that makes experiences possible. According to Kant, the human mind possesses "sensibility," which delivers experiences, and "categories" which organize those experiences and provide understanding.

There are two elements of sensibility, space and time, which supply the mind with perceptions. There are 12 ordering categories, which Kant derives from Aristotle's logic, with four broad classes of quantity, quality, relation, and modality, each divided into three subclasses. Examples of the categories are "substance" and "cause." The idea of substances with attributes and the idea of universal causation are not given to us in experience but are provided by the mind and impose order on our perceptions. Since these structural features of the mind are innate in human beings, the world appears to all people in essentially the same form. William Golding's (1955) novel *The Inheritors* is a brilliant attempt to capture what the world might have looked like to Neanderthal people in contrast to our world. In the case of the Neanderthal mind, the sensibilities and categories are not quite fully established.

In short, we can only have the experiences we have because of our minds, and so there is a necessary correspondence between the structure of the mind and the way the world appears. Logic, mathematics, and sciences such as physics, Kant argues, also depend on the concepts of space and time and the 12 categories, and it is this that makes it possible for them to be successful and to add to our stock of knowledge. They are able to produce knowledge that is universally true. This is the case even though we can never have access to the external world that provides the things we sense, i.e. the noumena or things in themselves. We will never know about the world of noumena. We are human beings who observe the world through our senses so we can only ever know things as they appear. Scientific knowledge is only possible because it restricts itself to elucidating what the mind makes available through the senses.

We now have a reason, although admittedly a topsy-turvy one, for accepting the knowledge produced by science. But what are, for Kant, the limits of scientific knowledge? Clearly, it carries no weight in fields such as psychology or in answering metaphysical questions about the existence of God, the immortality of the soul, and free will. This is because the subject matters of psychology and metaphysics lie beyond what we can observe with our senses and so what science can explore on the basis of space and time and the categories. As Kant argued, thoughts without content are empty. We can prove anything and so are led into contradiction. That does not mean that reflection on these matters is pointless, just that in the case, for example, of seeking principles to guide human conduct, we have no choice but to venture beyond the knowledge that science can provide.

It is now possible to consider the second reason for Kant's importance for systems thinking. At the time that he was beginning his philosophical work, the mechanistic view, insisting that all life forms had remained the same since their creation, was being questioned from an "organicist" perspective. Kant was much influenced by this thinking and agreed that it was impossible to provide a mechanical account of organic processes such as change, growth, and development. The vitality and diversity of nature seemed to require a different kind of explanation that accepted the emergence of new and more complex organisms. As he wrote: “Are we in a position to say: *Give me matter and I will show you how a caterpillar can be created*?” (quoted in Mensch 2013, loc. 234). Kant was now in a dilemma because his arguments for what constituted scientific knowledge, later set out in the “Critique,” only permitted mechanical explanations. There seemed to be a requirement for organicist thinking in the “life sciences” but using it meant it was impossible to attain the same certainty as in mathematics and physics.

Kant returned to this issue in earnest in his *Critique of Judgement*. In terms of scientific reasoning, he argued, it is indeed impossible to support organicism because this would take us “beyond the mechanism of blind efficient causes” (quoted in Kemp 1968, p. 114). On the other hand, using a simple example, biologists are not going to get very far in studying the human heart if they restrict themselves to the question of “how did this come about?” and ignore the question of “what is this for?” Teleological explanation employing a form of causality directed to ends, in this case the parts serving the purposes of the whole, is essential. Kant's solution is to argue that, while it cannot be fully justified, it seems to be of considerable heuristic value to assume purposiveness of this kind in nature. Organicism is essential to pursuing studies in the life sciences even if it does take us “beyond the world of sense” (Kant, quoted in Kemp 1968, p. 114). This will always be the case because of the unavoidable limitations on our thinking. Nature is just too complex to be encompassed by the human mind. Kant is here anticipating a conclusion of Checkland's (see Chapter 16) that systemicity is best seen as an epistemological device to inquire into the world rather than assumed to be a characteristic of the world. As Mensch has argued, not all of Kant's followers were quite as theoretically scrupulous:

> Convinced of nature's vitality, naturalists and philosophers would make use of Kant's work as they saw fit. The most significant transformation of Kant's work concerned the use of transcendental principles themselves, since these tools for *thinking* about nature would be subsequently ascribed to nature itself.
>
> (Mensch 2013, loc. 420)

As an aside, Mensch (2013) has argued that the organicist perspective had a major impact on Kant even in the *Critique of Pure Reason*. Alongside its job of constructing experiences, Kant thought, the mind must also integrate them. Ultimately this depends on the self, a single consciousness to which thoughts, reflections, and intuitions are related (Kemp 1968). In creating such a unity, the mind must operate according to some sort of organic logic. According to Mensch,

> … like an organism, cognition functioned [for Kant] as a set of parts whose thoroughgoing connection realized unity even as the grounds of that unity preceded it. This was a different logic at work … it was a reflexive logic according to which the unity of apperception was both cause and effect of itself, or, as Kant would put it in another context, both author of and subject to its own laws.
>
> (Mensch 2013, loc. 374)

This is an interesting foretaste of the notion of the mind, or "psychic system," as a self-producing system that will be discovered in Luhmann's systems theory in Section 4.7.

On the subject of human behavior, and here we come to his third great contribution to systems thinking, Kant faced a problem even more severe than he had encountered with nature. According to science, the self must be subject to the laws of causality just as are all other phenomena in the realm of appearances. In order to uphold the notion of morality, however, we need to believe in the existence of free will. In the *Critique of Practical Reason*, Kant sets out his solution. As phenomena, humans are subject to causal determinism. However as "things in themselves" (noumena), beyond the reach of scientific knowledge, it is completely legitimate to regard them as possessing freedom:

> We have in the world beings of but one kind whose causality is teleological, or directed to ends, and which at the same time are beings of such character that the law according to which they have to determine ends for themselves is represented by themselves as unconditioned and not dependent on anything in nature, but as necessary in itself. The being of this kind is man, but man regarded as noumenon.
>
> (Kant, quoted in Kemp 1968, pp. 120–121)

Having demonstrated that it is possible to believe in free will, Kant argues that it is essential to do so. Although it may not be theoretically justifiable, from a practical point of view, it is necessary to believe in freedom of choice just because morality depends on it. On the basis of such "practical reason," it then becomes possible to establish proper rules of human conduct. In order to be sure that they are acting morally rather than according to their individual desires, humans must be able to universalize their actions. Kant's famous "categorical imperative" follows: "Act only on that maxim which you can at the same time will to be a universal law." (This is sometimes formulated as always treating people as ends in themselves, never as means to an end.) So, for example, borrowing money without intending to pay it back fails the test because it treats the lender as a means and undermines trust and the possibility of future borrowing for other humans. It also turns out that belief in God and an immortal soul is rational from the perspective of practical reason. Only God can guarantee a fair correspondence between the virtue we display and the rewards we receive, and only immortality can provide for its delivery. Freedom, God, and immortality may not be laws of nature, but they are powerful laws of morality.

Before leaving this section, it is worth reflecting on the considerable impact Kant's philosophy continues to have on Western culture. There are, for example, numerous speculations on what it might be like to escape the world of appearances and see "things in themselves" and various proposals as to how this might be achieved. Not all acknowledge Kant, but it is Kant's influence that is at work. Huxley (1959) experimented with the drug mescaline to try to break through the "eliminative" function of the brain and sense organs. Castaneda sought the guidance of a Yaqui Indian, don Juan, to get beyond the *tonal*, "the organizer of the world," and to witness the *nagual* (the Yaqui equivalent of noumena) and is warned, along the way, that:

> Ordinarily, if an average man comes face to face with the *nagual* the shock would be so great that he would die.
>
> (Castaneda 1974, p. 174)

In the science fiction film *The Arrival* (Denis Villeneuve, director, 2016), it takes mastering an alien language to allow humans to escape the tyranny of space and of time as a linear phenomenon. Adam Roberts' novel *The Thing Itself* speculates that artificial intelligence (AI) might achieve what humans can't:

> And we've discovered that, once you abandon the notion of trying to *copy* human consciousness, AI is really quite easy to achieve .... You've done this? ... Sure ... A rational, sentient, intelligent consciousness, unfettered by the constraints of space and time? One that can see into the Ding an Sich [thing in itself]? .... Essentially, yes. Pretty much.
>
> (Roberts 2015, p. 92)

Returning to the argument of the book, Kant's philosophy provided a kind of inverted justification for what mathematicians and physicists were doing in their own fields. They were gaining knowledge by learning how the human mind structures reality. It also gave a warning to scientists who sought to extend the mechanical model into the domains of the biological, human, and social domains. These warnings were rarely heeded as many sought to increase the scope of the scientific method even as far as psychology and sociology. For the moment, we shall continue to explore how later philosophers engaged with Kant's conclusions on the limitations of the human mind and how they impact on what we can know with certainty.

1.3 Hegel

Hegel, writing at the beginning of the nineteenth century, criticized Kant for his a-historical account of mind. For Hegel, the mind gives rise to reality but, at the same time, is itself historically conditioned. The mind is the driving force of history but has tended to externalize itself in an alienated way in which customs and institutions seem to stand above and control human action. However, during the Enlightenment, thinking has progressed to the stage where it is able to understand its true destiny. "The history of the world," Hegel wrote, "is none other than the progress of the consciousness of freedom" (quoted in Honderich 1995, p. 339). It was now possible for humans, with their common capacity for reason, to take control of history and build a truly free community to which they can all assent because it is a rational expression of their will. Thought frees itself from history and becomes capable of determining its future course. Society ceases to be alien and hostile to people because it is a reflection of their rational intentions.

In Hegel's "absolute idealism," the dualisms of mind and nature and subject and object are overcome because there is only mind and mind determines reality. The process by which mind is able to overcome its historical limitations and gain a holistic understanding of itself is called "dialectical." Comprehension of the whole, "the absolute," is gained through a systemic unfolding of partial truths in the form of a thesis, an antithesis, and a synthesis, which embraces the positive aspects of the thesis and antithesis and goes beyond them. Each movement through this cycle, with the synthesis becoming the new thesis, gradually enriches our grasp of the whole system. An example given in Honderich (1995, p. 342) is of "the customary morality of ancient Greece [as] the thesis, the Reformation morality of individual conscience its antithesis, and the rational community [as] the synthesis of the two."

1.4 Pragmatism

One way of reading the work of the pragmatist philosophers, Pierce, James, and Dewey (writing in the United States in the late nineteenth and the early twentieth century), is as a response to Kant's concern about how to proceed in the noumenal world, beyond the sway of science as he strictly defined it. This realm is vast, embracing such matters as the behavior of organisms, the free will of humans, the purpose of social organizations, morality, esthetics, as well as all aspects of theology. The pragmatists found a clue in Kant's very definition of pragmatic belief. He had written that "contingent belief, which yet forms the ground for the effective employment of means to certain actions, I entitle *pragmatic belief*" (quoted in Honderich 1995, p. 710). Their response was to seek a justification for belief and action in terms of its practical effectiveness. They differed among themselves, however, about the scope of this justification and about who should decide whether the standard set had been met. Pierce, the most restrictive of the three, felt that it could be used by scientists to extend their knowledge by taking predictive success as the main criterion for deciding between competing theories. James felt that the justification could be extended to the rightness of actions as judged by individuals. Dewey's interest was in the resolution of problems, which meant knowledge was confirmed only when it was recognized by the community as being successful in transforming practice so as to overcome problems. Ormerod precisely summarizes the situation:

> Peirce's pragmatism is scientifically élitist, James's is psychologically personalistic, Dewey's is democratically populist.
>
> (Ormerod 2006, p. 893)

Let us follow the thinking of James (particularly as described in Passmore 1970), who was the main popularizer of pragmatism with his 1907 book *Pragmatism: A New Name for Some Old Ways of Thinking*. James rejected, as did all the pragmatists, what Dewey called the "the spectator theory of knowledge," which presented knowledge as a passive reflection of some external reality. To him the world had a "concatenated unity," experienced by human beings not as divided into parts but as a "stream of consciousness." Individuals had to impose a structure upon the wholeness of everything – upon the "blooming, buzzing confusion," as he described a baby's first experience of the world. The question for James, therefore, became what was the best way of using concepts to create order. Since reality is not static but in process, the pragmatic answer is to employ ideas that are effective in the long run in helping realize our goals and objectives and so bring benefits. True beliefs are those that prove useful over time as judged by the individuals concerned. James is excited about the free will his account lends to human beings. Because reality is in the making, they have the capacity to change and improve the world in which they live. "The greatest discovery of my generation," everyone quotes him as saying, "is that a human being can alter his life by altering his attitudes of mind." This freedom is constrained, however, because all ideas and actions are subject to an empirical reality check. If their consequences do not prove fruitful, then they will have to be abandoned.

1.5 Husserl and Phenomenology

Husserl is another philosopher who has had a major influence on systems thinkers. He wrote his major works on "phenomenology" in the early years of the twentieth century. The term phenomenology indicates that his interest was in phenomena, "things as they appear to our senses" (as Kant would say), rather than in speculating about any independent reality. Indeed, to develop a science of pure consciousness, which is the aim of phenomenology, it is necessary to "bracket" our "natural attitude" that things like trees and tables exist and cause our sensations. Once this is achieved, it becomes possible to go directly "to the things themselves" and begin a rigorous investigation of the common features of all acts of consciousness and of how the mind constitutes and experiences the world.

For Husserl, all conscious mental activity, whether linked to sensory perception, the imagination, or our emotions, is thinking about something. Philosophy is about uncovering how the mind addresses and gives meaning to the world through "intentionality." In his later work, this thinking took him closer to Hegel's philosophy (see Honderich 1995) as he became interested in the historicity of consciousness. He began to see experiences as conditioned by the traditions and social context of the time. They are part of a "life-world," which we share with others and largely take for granted. Science itself emerges from this life-world and is dependent on it for the research it does, the evidence it collects, the experiments it conducts, and the way it interprets its results. It has, however, been losing touch with the life-world since its "mathematization," following Galileo, and has nothing to say now about the really important issues of concern to humankind:

> In our vital need … science has nothing to say to us. It excludes in principle precisely the question which man, given over in our unhappy times to the most portentous upheavals, finds the most burning: questions about the meaning or meaninglessness of this whole human existence.
>
> (Husserl 1970, p. 6)

Husserl's attention to how individuals actually experience the everyday world was attractive to many philosophers and established a phenomenological tradition (see Bakewell 2017). His even more famous or infamous protégé, Heidegger, shaped phenomenology into an investigation of "being" and especially the mode of "being-in-the-world" in a particular social context. In his later work, Heidegger became concerned with a change in "intentionality" – in the way the mind relates to things as its objects. The proper purpose of human consciousness is to "reveal" the nature of being and the tools of phenomenology can be employed to this end. In contemporary society, however, this possibility is endangered by the advance of an "enframing" mentality. This is clearly expressed in modern technology, which presents both nature and human beings as a "standing reserve," ready to be used for some instrumental purpose. Commenting on the relevance of this thinking to the Internet, Bakewell comments:

> Later Heideggerians, notably Hubert Dreyfus, have written about the internet as the technological innovation that most clearly reveals what technology is. Its infinite connectivity promises to make the entire world store-able and available, but, in doing so, it also removes privacy and depth from things. Everything, above all ourselves, becomes a resource, precisely as Heidegger warned.
>
> (Bakewell 2017, p. 324)

A particular strand of phenomenology, pioneered by Jean-Paul Sartre and Simone de Beauvoir, became known as "existentialism" and gained significant popular appeal. Sartre read the notion of "intentionality" as suggesting that the mind has immense freedom to interpret the world as it wishes. Individuals are influenced by biology and social conditioning, but they have no predefined nature. "Existence precedes essence," and people are free to decide how to live and act. This radical freedom is frightening to many, and they reject the responsibilities it brings by taking on a ready-made role in the life-world. Sartre explored, in novels and plays as well as philosophical writings, how it is possible for individuals to escape their apparent destiny and live free of "bad faith." Later, reacting to the Second World War and the events surrounding it, Sartre's primary concern became how we should use our freedom. Thus began a life-long endeavor to fuse elements of phenomenology and Marxism into a practical program of action. Deciding that "truth" could only be established by looking at the world through "the eyes of the least favored" or to "those treated the most unjustly"

(Bakewell 2017, p. 271), Sartre was led to support a variety of radical causes and groups and to reject the Nobel Prize in literature. Meanwhile his partner in life and in developing existentialism, Simone de Beauvoir, was using "applied existentialism" to explore the history of patriarchy and how it plays out as individual women lead their lives from birth to old age. Her great book *The Second Sex* argues that a female is not born but becomes "a woman" as she takes on the dominant male perspective and sees herself through the "male gaze." Women need to stop seeing themselves as "objects" and assert their subjectivity. They can then confront the world as it really is for them, break out of gendered roles, and change their lives. Bakewell considers *The Second Sex* as the most influential work to emerge from the existentialist movement and as deserving of a place alongside those of Darwin, Marx, and Freud as "one of the great cultural re-evaluations of modern times" (2017, p. 216). It is difficult to argue with this conclusion. The two central notions of "applied existentialism" – of always siding with the oppressed and of liberating "slaves" from the perspective of their "masters" – made existentialism popular with anti-colonialist writers and campaigners such as Albert Memmi and Frantz Fanon. Both were championed by Sartre and de Beauvoir. Black American writers, such as Richard Wright and James Baldwin (who was also gay), turned up in Paris to absorb the doctrine of existentialism and to experience a freedom denied to them in their homeland. Another influential French existentialist, Maurice Merleau-Ponty, contributed to systems thinking in a different way. He introduced the idea of the human body, with its hands, feet, etc., as a primordial and permanent condition of experience. He also argued, following the *Gestalt* psychologists, that we make sense of the world through unified and meaningful "wholes" rather than clearly delineated individual perceptions. The wholes we construct are ever changing according to the intentionality guiding our observations.

1.6 Radical Constructivism

Radical constructivism may be little more than a footnote in the history of mainstream philosophy, but it has contributed significantly to the development of second-order cybernetics (see Section 6.4). It is associated primarily with the work of von Glasersfeld, who was writing in the late twentieth century. von Glasersfeld took his inspiration from the genetic epistemology of Piaget. Piaget's theory stated that cognitive development in children occurs as mental processes reorganize themselves as a result of the interaction between biological maturation and environmental experience. "Intelligence organizes the world by organizing itself," he wrote (quoted in von Glasersfeld 1984, p. 5). At various stages of their development, children engage with the world and understand it differently. For von Glasersfeld (1984), this was confirmation of Kant's argument that our minds do not reflect some external reality but construct that reality from what is provided by experience. In contradistinction to Kant, however, von Glasersfeld goes on to emphasize the considerable freedom this provides to human beings because of the extremely rich raw material that the experiential world provides. The world out there presumably imposes some boundaries on what is possible, but these are very broad. We are not governed in our thinking by immutable Kantian "categories" but only by the opportunities presented by the history of the construction process to date. In this respect, von Glasersfeld argues,

> ... the theory of evolution can serve as a powerful analogy: the relation between viable biological structures and their environments is, indeed, the same as the relation between viable cognitive structures and the experiential world of the thinking subject. Both *fit* – the first because natural accident has shaped them that way, the second because human intention has formed them to attain the ends they happen to attain; ends that are the explanation, prediction, or control of specific experiences.
>
> (von Glasersfeld 1984, p. 4)

Just as the natural environment allows for many types of organism, so the experiential is forgiving of many ways of understanding and being in the world. von Glasersfeld criticizes pragmatist philosophers because they foster the temptation to seek access to an "objective" world on the basis of "effectiveness" but "effectiveness" he argues "is a judgement made within a domain of experience which itself was brought forth by an observer's activity of distinguishing" (1990, p. 3). In radical constructivism, viability replaces truth as the key concept because, however much we push against the world "out-there," all we can ever learn is whether the cognitive apparatus we have developed provides one *fit* among all those that might be possible. Returning to Piaget, a very young child possesses a viable cognitive structure even though it is incapable of logical or abstract thought. The child learns through physical actions and monitoring their results to construct a relatively stable world in which its needs are met. It does not gain objective knowledge about reality. The degree of cognitive freedom implied by radical constructivism leads von Glasersfeld to stress, again and again, the personal responsibility we all have for our words and deeds.

1.7 Conclusion

The philosophical ideas set out above are those that are of most relevance for examining the different ways of using systems ideas in management that will be considered in Part III of this book. For the moment, we pass onto other disciplinary areas and detail their impact upon the development of systems thinking. In a sense, though, the next three chapters are a continuation of the debate with Kant's philosophy. His insistence on Newton's mechanical model as the exemplar of knowledge in the physical sciences was not seriously challenged until the genesis of general relativity and quantum mechanics. His organicist approach to the life sciences continued to be influential until Darwin's theory of evolution provided an alternative to teleological explanations in that field. Social sciences, such as psychology and sociology, can be regarded as correctives to the notion of the "autonomy of the will" that underpins his reflections on proper human conduct.

2
The Physical Sciences and the Scientific Method

If we possessed a thorough knowledge of all the parts of the seed of any species of animal (e.g. man), we could from that alone, by reasons entirely mathematical and certain, deduce the whole figure and conformation of each of its members

(Descartes, *Oeuvres* 1897, iv, 494, originally from the 1630s)

2.1 Introduction

Newton's *Principia* (1687) set out his laws of motion, his theory of universal gravitation, and a new cosmology. It was the apotheosis of the Scientific Revolution, which had begun with Copernicus' challenge to Ptolemy's earth-centered model of the universe. That revolution produced a huge growth of knowledge in fields such as mathematics, physics, astronomy, chemistry, and biology. To many scientists, it seemed that everything would soon be known. Further, the technologies that stemmed from the advances in science transformed the world in which we live. There were revolutions in agriculture and industry leading to massive increases in productivity and the rapid growth of urbanization. These, together with better prevention and treatment of disease, led to population growth and longer life expectancy. Roads were improved, canals and railways were built, and shipping lines developed, increasing trade and making the world a smaller place. Despite frequent wars and the continuance of poverty, it seemed that progress toward a better society was being made and that this would continue.

The achievements of science in opening up the physical world to our understanding are said to stem from the method it employs to gain knowledge. Sir Hermann Bondi, the distinguished mathematician and astronomer, declared: "There is no more to science than its method ..." (Lewens 2015, loc.140). It is this scientific method that we must explore to reveal why it is so successful in enabling mastery of many aspects of the physical world and what limitations there are to its proper use in this domain and in other fields.

2.2 The Scientific Method and the Scientific Revolution

An excellent account of the evolution of the scientific method, in terms of its relevance to systems thinking, is provided by Checkland (1981). It begins with the pre-Socratic philosophers of ancient Greece who, eschewing explanations relying on magic or the Gods, employed "rational thought" to develop and defend their conclusions. Further contributions were made by the great Muslim thinkers who rediscovered the significance of Aristotle's work and who made advances in mathematics and optics. The mediaeval alchemists added to the mix with their zeal for experimentation.

The decisive moment came in the early seventeenth century through the efforts of Francis Bacon and Galileo. Bacon thought deeply about how to do science. In his view, scientists should give precedence to studying nature directly and not through the works of Aristotle. He advocated close observation of the facts, the development of hypotheses from those facts and directed experiments to test the hypotheses. The results of the experiments should be recorded and reported so that progress was cumulative. In this way, science could help improve man's lot on earth (Chalmers 1982; Checkland 1981). Galileo's practice as a scientist gave substance to Bacon's words. He was wedded to the facts obtained from observation and defended what he saw. The moons of Jupiter existed, he insisted, and were not aberrations of his telescope because if they were aberrations he would see moons around other planets as well (Chalmers 1982). He established the experimental method as the norm in science; most famously measuring the time it took spheres of different weights to reach the ground when dropped from the top of the Leaning Tower of Pisa. His experiments were designed to test particular hypotheses. The details and results were written up so that they could be repeated and validated by other scientists in different places. Where he went beyond Bacon's thinking was in his commitment to mathematics as the language of science. If at all possible, theories and experimental demonstrations were expressed in mathematical terms.

In the early years of the seventeenth century, therefore, a best way of doing science, a well-defined "scientific method," was established. This can be summarized as having five steps. First a part of reality, of interest to the scientist, is separated from the rest (in the scientist's mind) and observed. Second, on the basis of numerous observations, a hypothesis is constructed, in mathematical terms if possible, setting out how some of the variables that make up that part of reality behave. This move from a finite number of observations to a possible universal law is known as induction. Third, deductions are made and predictions formulated about how the variables will behave in the future. Fourth, carefully devised experiments are conducted to test the predictions and the results of these measured. The experiments must be clearly described so they can be repeated by other scientists. Finally, the results are analyzed and conclusions reported setting out whether the experiments confirm or disprove the hypothesis. On this basis, the progress of science is guaranteed.

In Descartes' opinion, the success of this scientific method was due to its "reductionism." A part of the real world is isolated from the rest for study and then broken down into separate objects or variables for further analysis. The logic of mathematics is used to build back up to an understanding of the whole. He used his considerable philosophical weight in support of this approach. Writing in 1637, he argued that, if he wanted to understand the world and the problems it posed, it was essential to proceed by the method of reductionism

> … to divide each of the difficulties that I was examining into as many parts as might be possible and necessary in order best to solve it [and] beginning with the simplest objects and the easiest to know … to climb gradually … as far as the knowledge of the most complex.
>
> (Descartes 1968, pp. 40–41)

The validity of this mechanistic perspective, in which the whole is no more than the sum of its parts, seemed to be confirmed, later in the century, when Newton used the scientific method to realize his supreme achievement of uniting terrestrial and celestial mechanics. For example, his hypothesis about gravity as a universal force was refined into equations, which enabled accurate predictions to be made about the movement of objects on earth and planets in the sky. The universe was like clockwork set in motion and sustained by God and followed entirely predictable rules that could be understood by humans. As Buchdahl summarizes it:

> [Newton's] synthesis of empirical data and abstract mathematical relations which are here united to lead to accurately verifiable observations, impressed [his] contemporaries by seemingly bestowing the certainty of mathematics upon man's knowledge of physical phenomena, and gave them a new sense of power over nature.
>
> (Quoted in Checkland 1981, p. 44)

The success of the Scientific Revolution led to the almost complete dominance of Cartesian mechanism during the eighteenth and nineteenth centuries. Scientists refined Newtonian mechanics to provide precise explanations of the behavior of solids, liquids, and gases, and phenomena such as sound and the tides. In 1814, the mathematician Laplace was able to assert that Newton's laws could in principle be used to predict everything for all time as long as the current position and velocity of all the particles in the universe were known (Mitchell 2009, p. 19).

The most significant extension of science in the nineteenth century followed in the same tradition. It was achieved by applying Newtonian mechanics to thermal phenomena and “treating liquids and gases as complicated mechanical systems” (Capra and Luisi 2014, p. 32). This gave rise to “thermodynamics” and the discovery of its two fundamental laws: the law of the conservation of energy and the law of the dissipation of energy. The second of these is particularly important for our purposes since it argues that all isolated systems, such as the universe, inevitably dissipate mechanical energy and move from order to disorder. In the jargon, entropy, as a measure of disorder, gradually increases as useful energy is lost in the form of friction or heat. In the words of Capra and Luisi: “The entire world-machine is running down and will eventually grind to a halt” (2014, p. 33). This, of course, causes a problem for those who perceive the living and social worlds as apparently increasing in order and complexity. The development of thermodynamics was made possible by the invention of statistical mechanics, essentially a combination of statistics and probability theory with

Newtonian mechanics (Capra and Luisi 2014, p. 104). Newton's equations of motion were notoriously difficult to solve when applied to more than a few bodies exhibiting regular behavior. In fact, at the time, even three bodies precluded precise solutions. So how could scientists proceed when confronted by, for example, gases with millions of molecules? A solution was found by the physicists Ludwig Boltzmann and James Clerk Maxwell. They accepted that it was impossible to predict the behavior of all the molecules individually but reasoned that, as each molecule acted independently, statistical methods could be applied to predict their average behavior. Because of the myriads of molecules involved, this corresponded almost exactly to their actual overall behavior. Thus, they were able to derive the laws of motion of gases by using the average behavior of molecules.

By the end of the nineteenth century, therefore, as Capra and Luisi say,

> ... scientists had developed two different mathematical tools to model natural phenomena – exact, deterministic equations of motion for simple systems; and the equations of thermodynamics, based on statistical analysis of average quantities, for complex systems.
>
> (2014, p. 104)

They could be forgiven for believing that they were involved in an enterprise that was steadily discovering the truth about the world. Further, and despite Kant's cautionary warnings, they thought that the scientific method that was bringing such success in physics could be extended with equally positive results to other fields. Dalton's work on the physical behavior of gases led, in the nineteenth century, to the formulation of an atomic theory of chemistry with the promise of explaining all chemical phenomena using physics (Capra and Luisi 2014, p. 30). It surely would not be long before biology, and perhaps even social systems, would succumb to scientific explanations and be seen as nothing but complicated expressions of the laws of physics. The physicist Albert Michelson proclaimed in 1894 that

> ... it seems probable that most of the grand underlying principles have been firmly established and that further advances are to be sought chiefly in the rigorous application of these principles to all phenomena which come under our notice.
>
> (Quoted in Mitchell 2009, pp. ix–x)

Systems ideas were pushed to the margins, championed only by a few in the life sciences and those artists, writers, poets, and philosophers working under the banner of "romanticism."

The revolutions in thinking in the physical sciences in the twentieth century, however, have shattered the self-assurance of scientists and led to doubts being expressed about the nature and scope of application of the scientific method as previously described. It is to these matters that we now turn.

2.3 The Physical Sciences in the Modern Era

Gleick (1987) has argued that twentieth-century science will be remembered for three things: relativity, quantum mechanics, and chaos theory. What all three announce and share in common is a revolutionary transformation of understanding. Scientists have had to abandon the mechanistic and deterministic assumptions underlying the Newtonian worldview and embrace a perspective that is more systemic in character.

Einstein revealed his general theory of relativity in 1915 following long reflection on the contradictions that existed between Newton's law of gravity and his own special theory of relativity. Newton saw the universe as a great empty box within which gravity operates to determine the motion of objects. He conceived of gravity as a force of attraction possessed by all objects with its power dependent on how far apart they are and their mass. As Rovelli (2015, p. 5) suggests, this is a mechanical world where objects eternally travel on long precise trajectories, determined by gravity, in geometrically immutable space. In Einstein's vision, however, space-time and matter/energy are inextricably linked. Large objects, like the sun, bend space-time around themselves. The warped space-time causes the path of objects to be curved because this is the shortest route it offers. Planets revolve around the sun because space is curved. The curvature of space and gravity are the same thing. At the heart of Einstein's theory is a loop in which, in the words of the physicist John Wheeler: “Space-time tells matter how to move; matter tells space-time how to curve” (quoted in The Economist 2015). This magnificent theory, captured in elegant mathematics, was soon confirmed by experiments demonstrating that the sun does cause light to deviate and that time does pass more quickly higher up than closer to the earth. Later, it led scientists to discover black holes and to determine that the universe was born with the “big bang” and was continuing to expand. In short, says Rovelli,

> ... the theory describes a colourful and amazing world where universes explode, space collapses into bottomless holes, time sags and slows near a planet, and the unbounded extensions of interstellar space ripple and sway like the surface of the sea.
>
> (2015, p. 9)

At once, Einstein had surpassed Newton's theory, hitherto regarded as the pinnacle of scientific achievement, and called into question Kant's philosophy, dependent as it was on Newton's mechanics and Euclid's geometry. Perhaps science could see beyond the sensibilities and categories as envisaged by Kant. Einstein had produced a theory of the universe as a more organic entity, more interconnected and dynamic, than anything previously envisaged.

The next revolutionary development in twentieth-century physics, quantum mechanics, was a step too far even for Einstein. In general relativity, everything is still certain. There is an objective reality “out there” that behaves in a deterministic fashion independently of how it is observed. In quantum theory, nothing is stable and particles can be both here and there simultaneously depending on their interrelationships. This theory, of matter and energy at the atomic and subatomic levels, originated in the work of Max Planck and Einstein himself and found its fully developed form in the results published by Niels Bohr and Werner Heisenberg in 1925. Their equations describe a world completely at odds with Newton's deterministic perspective. According to the widely accepted “Copenhagen” interpretation of the results, incorporating Heisenberg's famous “uncertainty principle,” particles do not exist in any definite “place.” Much to Einstein's frustration, quantum mechanics allowed God “to play dice.” Electrons come in and out of existence as they jump from one interaction to another and it is impossible to be certain where they will reappear. It is only possible to calculate the probability of them surfacing in one place or another. Indeed, they only seem to come into existence when interacting with other systems, for example, measuring instruments used by observers. Furthermore, the interactions do not have to be “local.” “Spookily,” in Einstein's view, particles are “entangled” with one another such that if one changes, there can be an immediate impact upon another even across vast distances:

> No one knows how it works. The entangled particles are chained together by a connection that we don't understand. They may be one particle that manifests in our world in two separate places. They may even be, by some hidden, contorted geometry of space, right next to each other.
>
> (Brooks 2017, p. 164)

It is impossible to predict the position of each particle but only to evaluate the “quantum state” of the system as a whole. Rovelli is convinced that “reality is only interaction” (2015, p. 18). Despite Einstein's doubts, it is now fully accepted by scientists that quantum mechanics provides an accurate account of the behavior of tiny particles and forces. And the theory is used in an increasing number of real-world applications, for example, to build ultra-precise clocks, unbreakable codes, better microscopes, and super-powerful computers. If quantum mechanics deals in probabilities that is not because it lacks knowledge, it is because that is the way the world is.

In the 1960s and 1970s, Gleick's third hallmark of twentieth century science began to take shape in the form of chaos and complexity theory. Chaos and complexity theory lays claim to being the science of the global nature of systems and is considered fully in Chapter 7. For the present, it is enough to highlight how the theory aims to extend the reach of classical science. Classical science sought to discover orderly, regular patterns of behavior, based on cause–effect relationships, from which fixed laws could be derived. This emphasis, according to Gleick, led it to ignore “the irregular side of nature,” those things that were erratic and discontinuous. These phenomena remained puzzling to science. They appeared as “monstrosities.” However, around 50 years ago, a small number of scientists came face to face with the “erratic side” of nature and began to think along different lines. Two discoveries earned chaos theory an important place in science. First, it was found that complex and unpredictable behavior could emerge in systems constructed on the basis of entirely deterministic equations. There was no need to introduce any probabilistic element. Second, it was a common finding of the early pioneers that there is considerable order underlying chaos. Chaos did not therefore, as in everyday language, imply anarchy. In the zone between stability and instability, general patterns of behavior emerge even if the specifics are unpredictable.

In the modern era, it is clear that science has abandoned mechanism and embraced concepts such as relationships, indeterminacy, and emergence. It is no longer at loggerheads with systems thinking. Indeed, the physical sciences have undergone their own systems revolution and are now able to make a contribution to systems thinking in other disciplines.

2.4 The Scientific Method in the Modern Era

The revolution in the way that the physical world is understood necessitated further reflection on the nature of the scientific method. The most famous twentieth-century philosopher of science is Karl Popper. To continue the quote from Sir Herman Bondi: "There is no more to science than its method, and there is no more to its method than Popper has said" (quoted in Lewens 2015, loc. 140). To Popper, it was obvious that Einstein had not come up with his theory of general relativity by carrying out repeated observations. Rather it had emerged almost fully formed, as a brand new way of seeing the world, from a series of thought experiments. In Popper's account, this could not be otherwise because theories always precede observations. Scientists are guided by the theory they currently hold in their minds (remember Kant and Hegel) to make certain observations, to see things in certain ways, and to interpret their observations in terms of the theory (Chalmers 1982; Lewens 2015). Science starts for Popper not with repeated observations but with bold conjectures about the nature of some aspect of reality, often provoked by problems encountered by earlier theories. It all begins with an imaginative leap.

Once that has occurred, the scientific method kicks in. Einstein's theory of general relativity was able to provoke such a revolution in science because it was so clearly formulated, in the language of mathematics, and so productive of new hypotheses that it laid itself open to experimental testing and therefore to the possibility of falsification. There are two points to make here. First, for Popper, bona fide science must be falsifiable. Astrology is not science because its statements are so vague that they do not lend themselves to testing. Marxism is not a science because it is so flexible that no contrary evidence seems able to refute it. If the working class does not rise in revolution, it is apparently because they suffer from false consciousness. Second, while the classical version of the scientific method depends upon induction as its criterion of truth, the more supportive evidence the better, Popper replaces this with falsifiability as a criterion of plausibility. Induction can never lead to certainty because there might always be black swans around the corner. Neither can falsifiability, but if one theory is more falsifiable than its rivals, and succeeds in making more accurate predictions, it is likely to be nearer to the truth. For Popper, science as a process proceeds by conjecture and refutation to arrive at the best available theories. Progress is made.

Kuhn (1970) took Popper's notion of the theory dependence of observations to its logical conclusion (a conclusion that Popper avoided) to develop his highly influential account of the structure of scientific revolutions. Kuhn argues that scientists, their thinking governed by some current theory, find it hard to see contradictory evidence and, even if they do so, are likely to try to reconcile it with their existing preferences rather than use it to challenge the theory. Newton's laws failed to predict accurately the movements of Uranus. Scientists did not abandon his laws but sought an explanation in the existence of another planet. This is not necessarily a bad thing. It led to the discovery of Neptune and that was then seen as a triumph for the theory.

Looking at the actual history of science, Kuhn argued that it proceeds through cycles of “normal science” and “revolutionary science.” A science becomes established when a scientific community embraces a single “paradigm” as the basis for their work. A paradigm is a set of general theoretical assumptions, laws, and techniques, to which they give their adherence. A period of normal science ensues as scientists accept the paradigm uncritically and explore the possibilities offered by it. Kuhn calls this “puzzle-solving” and sees it as essential since it allows the working out of the detail of a theory. Eventually, however, anomalies arise, which go to the heart of the existing paradigm and are impossible to reconcile with it. A period of uncertainty follows. However, it requires the appearance of a rival paradigm before scientists begin to abandon their existing theories. Science then enters its revolutionary stage. Eventually, if the scientific community as a whole shifts its thinking, the old paradigm is abandoned and the new one elevated to dominant status. There follows another period of normal science until a new batch of significant anomalies arises. This seems a compelling account of, for example, the dramatic shifts from Aristotle's to Newton's and then to Einstein's view of the world and the long periods of calm in between.

Where Kuhn becomes controversial is in his insistence that there are no logical reasons for choosing one paradigm over another. Paradigms offer different, incompatible ways of viewing the world and, because the world does not exist independently of the way we view it, all claims about reality are dependent upon the paradigm employed. To illustrate how the world can change according to the paradigm you adopt, Kuhn describes his encounter with Aristotle's *Physics* developed around 350 BCE. At first he found it incomprehensible but:

> Suddenly the fragments in my head sorted themselves out in a new way, and fell into place together. My jaw dropped, for all at once Aristotle seemed a very good physicist indeed, but of a sort I'd never dreamed possible.
>
> (Quoted in Lewens 2015, p. 88)

Paradigms are “incommensurable” and, ultimately, the “religious conversion” involved in embracing a new paradigm happens for psychological or sociological rather than objective reasons. An individual scientist may see the new paradigm as offering better career opportunities or a scientific community as bringing it closer to political and economic power. Scientists, forced to provide a rationale, may cite simplicity or greater predictive power but these reasons in themselves simply reflect the values of their particular scientific community. Kuhn, however, denies being a "relativist." Science does not progress toward the truth but as paradigm replaces paradigm, through a process akin to natural selection, some improvements in problem-solving capability do seem to accrue. Kuhn describes his writings "as a sort of post-Darwinian Kantianism" (Lewens 2015, p. 95). We see the world through the particular paradigm that inhabits our minds but paradigms, like species, do evolve.

In spite of this small concession, most natural scientists remain aghast at Kuhn's conclusions. Despite Kant's great work, they tend to be "realists" in the sense that they believe the real world exists independently both of themselves and their theories about it. They think they are gaining knowledge about how that real world works. After all, didn't Newtonian physics put a man on the moon and hasn't science advanced even more since Newton? In Hilary Putnam's words:

> The positive argument for realism is that it is the only philosophy that doesn't make the success of science a miracle. (Quoted in Lewens 2015, p. 118)

Scientists who adhere to this position have Roy Bhaskar and his theory of "critical realism" on their side. In *A Realist Theory of Science*, Bhaskar accepts (this account follows Mingers 2006) that knowledge production is the work of humans and, in "the transitive domain," is cognitively and culturally conditioned. In doing so, he avoids the "naïve realism" of the traditional scientific method and accepts that our knowledge is "relative" in this domain. At the same time, he wants to demolish the more extreme relativism stimulated by Kuhn. It is an "epistemic fallacy" he argues, encouraged by philosophy since Kant, to concentrate solely on the ways humans understand and arrange the world through their thoughts and customs. This can only yield an anthropomorphic view. Instead we should ask the question "What must reality be like for scientific knowledge to be possible?" If we do so, by prioritizing ontology over epistemology, we can establish that there is indeed a real world of objects and structures, independent of our observations, which causes what happens and what doesn't happen.

Bhaskar calls the real world, which exists independently of humans and their theories, the "intransitive domain of knowledge." In this domain, entities and structures, often unobservable, can generate events, some of which we observe. Occasionally, this will include the kind of regularities that the traditional scientific method seeks out. Bhaskar postulates a stratified reality made up of:

- The "real," the whole of reality with, at its base, objects and structures with enduring properties that can cause things to happen

- The “actual,” events (and nonevents) generated by the causal mechanisms in the real, including the empirical and
- The “empirical,” those events that happen to be experienced by humans

Scientists must proceed by “abduction” to postulate what hypothetical causal mechanisms might give rise to observed phenomena. The experimental method then allows them to identify the correct generative mechanism at work and to eliminate other alternative explanations along the way. A scientist, as a human being, might bungle a particular experiment but cannot change the laws of nature and so cannot cause the results. The justification for critical realism's account of a stratified reality, and faith in scientific experiments, comes primarily from the success of the technologies that have been derived from this thinking and method. The success suggests that science can provide rational grounds for choosing between competing theories and does enable correct causal laws to be identified. Bhaskar is challenged by critics who believe that his acceptance of relativity in the transitive domain fatally undermines any certainty he can have about the existence of a real world of objects, structures, and generative mechanisms. Critical realism is relevant to the social sciences, and the argument is pursued in that context in Chapter 4.

It was the hubristic claim of scientists, toward the end of the nineteenth century, that they had developed a method capable of uncovering “the truth.” The scientific method, rigorously applied, would enable them to find out everything about the nature of reality. Philosophers of science in the modern era have been led to question this. Science, at the end of the twentieth century, was left with two magnificent but contradictory accounts of the world, general relativity and quantum mechanics, and this has led to numerous theories seeking to reconcile them. Du Sautoy (2016) has identified seven “edges,” including chaos and uncertainty, that science can never cross and will always impose limits on what we can know with certainty. Perhaps science was just lucky in what it chose to study in the early days of the scientific revolution. As Rapoport has it:

> Fortunately for the success of the mechanistic method, the solar system … constituted a special tractable case of several bodies in motion. (Quoted in Weinberg 2011, loc. 289)

Today, hardly anyone claims that science is close to understanding everything, even in its favored domains of physics, cosmology, and chemistry.

2.5 Extending the Scientific Method to Other Disciplines

Physicists have been tempted to claim that the method that brought them success in their field should be extended to other disciplinary areas. This is captured in a remark reputed to have been made by Lord Rutherford: “All science is either physics or stamp collecting.” In fact, as we go up the levels of system complexity, through biological, ecological, human, and social systems, the problems encountered by mechanism just seem to grow. Aristotle's insight that the whole is more than the sum of its parts becomes more pertinent. This is considered in detail in the next two chapters on the life and social sciences. A brief synopsis here will not, however, be out of place.

Checkland (1981) characterizes the scientific method, drawing upon both the traditional and Popperian versions, as possessing three key elements: reductionism, repeatability, and refutation. In the case of reductionism, it is not clear how researchers in the life and social sciences can separate out a part of reality, be sure they have identified the key variables and, from studying those variables, work up to an understanding of the whole. With ecological systems, involving multiple organisms and their environments, the interconnectivities can be such that the relevant, significant variables are hard to find and certainly hard to separate out. The same goes for studying, for example, crime and low educational attainment in the social arena. These areas of research struggle to identify obvious boundaries and discrete elements. Furthermore, even if the whole could be decomposed and the parts subject to further analysis, there is a danger of missing what is most essential about such complex systems. In an organism, for example, the relationships between the parts seem to be at least as important as the nature of the parts themselves. Indeed, new properties that are not present in the parts emerge from the way the parts are organized, for example, life itself. Repeatability and refutation are also difficult to enact in the life and social sciences. With ecological and social systems, it is usually impossible (and often unethical) to carry out experiments of the kind recommended by the scientific method. The real world cannot be dragged into the laboratory for study. Nor can experiments be easily repeated because the systems of interest tend to change rapidly, not least in response to the experiments. It is impossible to replicate the exact same conditions for the experiments. The theory will need to change to keep up and that makes refutation a difficult business. In social systems, the situation is exacerbated because humans are self-conscious and have free will (at least as noumena) so it is necessary to take into account different beliefs and purposes, the danger of self-fulfilling prophecies, and the capacity of humans to refute any prediction made about them. It seems that the domain of application of the scientific method is much smaller than many had thought and hoped.

There is a further set of issues. The scientific method and its associated technologies have yielded some undoubted benefits, but they seem to demand “mastery” over the areas to which they are applied. As Heidegger (1978) has argued, in “The Question Concerning Technology,” they seek to “enframe” both nature and human beings, reducing them to a “standing reserve” on call for technological purposes. This leads to unforeseen consequences, which the scientific method struggles to deal with because they too pose “wicked problems” involving many interconnectivities and stakeholders. These unintended consequences are the “second-order effects” (Weinberg 2011) of the scientific, industrial, and information revolutions, and arguably they have generated the great majority of the intractable issues that decision-makers face in the complexity age, for example, climate change, environmental degradation, pollution, inequality, exclusion, poverty, energy, food and water shortages, the danger of global recession, a possible global epidemic, nuclear proliferation, terrorism.

2.6 Conclusion

So when reductionism and the scientific method cannot cope, indeed make things worse, what alternative is there? The answer provided by this book is to look to systems thinking as a complementary approach. The reasons are clear. It is holistic, takes seriously the idea that the whole can be more than the sum of its parts, and considers the consequences that flow from this. It accepts that there will be multiple perspectives on any problem situation. Indeed, it believes that alternative viewpoints are to be encouraged. There is much to be gained from systems thinking both for our understanding of the systems we hope to manage and for us as human participants in those systems. It was the romantic poet Wordsworth (1814) who put it best:

For was it meant

That we should pore, and dwindle as we pore,

For ever dimly pore on things minute,

On solitary objects, still beheld

In disconnection dead and spiritless,

And still dividing, and dividing still

Break down all grandeur …

3
The Life Sciences

When we try to pick out anything by itself, we find it hitched to everything else in the universe

(John Muir, nineteenth century campaigner for national parks in the US, quoted in Wulf 2015, p. 321)

3.1 Introduction

The doctrine, promoted by Descartes, that sees the workings and behavior of all organisms (except that driven by the human mind) as explicable by mechanical principles had some success in the life sciences. He was, for example, able to point to Harvey's achievement in describing how the heart pumped blood to the body and brain. By the second half of the eighteenth century, however, the mechanical model was beginning to break down both as a way of classifying and of understanding life forms. The sheer variety and vitality of life led to the development of an alternative perspective on nature in the writings of romantic poets, philosophers, and natural historians. This perspective, known as "organicism," regards life as a special phenomenon that cannot be understood simply by using the laws of physics. Kant was a supporter of the new thinking, but he struggled with the "teleological" explanations that the life sciences seemed to demand i.e. causes understood as fulfilling some end purposes. He could accept that it was useful to see organisms as having parts that functioned to ensure their survival. But, for him, there was an unfortunate corollary – the life sciences would never be scientific because they strayed beyond what could be understood through the "mechanism of blind efficient causes." His conclusion was that it was sensible to orientate our studies in this domain on the basis of organicism but that we could not then claim to know things with certainty. We can trace how these ideas were worked through in later centuries in what became biology and ecology.

3.2 Biology

The problems posed to the traditional scientific method by biological phenomena are severe. Organisms possess highly interrelated parts and seem to defy some of the laws of physics, for example, demonstrating the characteristic emergent behaviors associated with life. That said, the history of biological science can be seen as a series of pendulum swings between the dominance of reductionist and holistic explanations, and the outcome of that battle is still not determined.

Goethe, although better known now for his literary output, was in his day a serious contributor to debates about the biological structure of plants and

> Biology would be crippled if it did not depend on concepts outside the scope of physical concepts: organism, life, birth, death, sex, viability, adaptation, behavior, cell, organ, evolution, species, genus, class, phenotype, genotype, mutation, selection, clone, embryo, etc., etc..... Biological processes are simply too complex to yield to the analytic method.
>
> (1968, pp. xvi–xvii)

The best known of the organismic biologists today is Ludwig von Bertalanffy. This is because, as we shall see in Chapter 5, he extended the systems ideas he originally developed in biology and made them relevant to other fields through his "general system theory." In the process, he became one of the founding fathers of systems thinking as a trans-discipline. Here we are concerned with his writings on biology. The failure of physics to explain biological systems, von Bertalanffy argued, was because it only dealt with isolated systems, "closed" to their environments. Closed systems obey the second law of thermodynamics, increasing in entropy and reaching an equilibrium state where no energy can be obtained from them (see Section 2.2). The universe is presented as a machine that is gradually running down to randomness or disorder. However, von Bertalanffy asserted, many systems are "open systems" importing matter and energy from, and exporting them to, their environments:

> However, we find systems which by their very nature and definition are not closed systems. Every living organism is essentially an open system. It maintains itself in a continuous inflow and outflow, a building up and breaking down of components, never being, so long as it is alive, in a state of chemical and thermodynamic equilibrium but maintained in a so called steady state which is distinct from the latter .... Obviously the conventional formulations of physics are, in principle, inapplicable to the living organism *qua* open system and steady state ...
>
> (1971, p. 38)

Open systems can temporarily defeat the second law of thermodynamics. Living off their environments, importing complex molecules high in free energy, they can evolve toward states of increased order and complexity. Organisms, for example, can maintain themselves in a dynamic state far from "true" equilibrium, constantly changing while retaining their basic form. Many have argued (e.g. Emery 1969; Lilienfeld 1978) that von Bertalanffy's 1950 article *The Theory of Open Systems in Physics and Biology* (1969), which first rigorously distinguished closed and open systems, established systems thinking as a modern intellectual movement.

von Bertalanffy's importance to biology rests on his insistence that organisms must be grasped as a whole and that their behavior cannot simply be reduced to the laws of physics and chemistry. According to Drack (2009), he developed and emphasized three essential organismic principles. First, organisms are open systems capable of maintaining themselves in a dynamic state far from true equilibrium. Second, in this state, they can exhibit progressive internal organization of parts (differentiation, specialization, hierarchy). Third, they can protect their own integrity in the face of environmental disturbances by reaching the same final state in different ways from different initial conditions. This final characteristic was called “equifinality.”

Working about the same time as the organismic biologists, and expanding Bernard's concept of the *milieu intérieur,* was the American physiologist Walter B. Cannon. His major work, *The Wisdom of the Body* (1932, revised 1939), was concerned with the ability of organisms, and particularly our own bodies, to persist over many decades while consisting of extraordinarily unstable material and being open to the environment. For Cannon, living systems are marvelous in that they

> ... may be confronted by dangerous conditions in the outer world and by equally dangerous possibilities within the body, and yet they continue to live and carry on their functions with relatively little disturbance.
>
> (1939, pp. 22–23)

He refers to the processes that maintain stability as *homeostatic*; examples being the self-regulating mechanisms controlling glucose concentrations, body temperature, and the acid–base balance. He also speculates that it might be useful to examine industrial, domestic, and social organizations in the light of the organization of the body.

von Bertalanffy's and Cannon's work was warmly welcomed in other fields, such as engineering and management, but the immediate impact on biology was negligible. This was because, as Capra (1996, p. 77) argues, the 1950s saw yet another turn toward mechanism in the discipline. Research in molecular biology led to the discovery of the structure of DNA and, eventually, to the unraveling of the genetic code. Just as, in the nineteenth century, it had seemed that biological phenomena could be fully explained by laws pertaining to the cellular level, now it appeared that they could be understood in terms of the molecular structure of the gene. The gene became the new elementary unit of “reductionist” biology and:

> The exclusive focus on genes ... largely eclipsed the organism from the biologists' view. Living organisms tended to be viewed simply as collections of genes, subject to random mutations and selective forces in the environment over which they have no control.
>
> (Capra and Luisi 2014, p. 42)

Richard Dawkins (1976) book *The Selfish Gene*, arguing for genetic determinism, was the radical intellectual expression of this movement and the Human Genome Project its crowning glory.

Molecular biology has indeed taught us a great deal about what the body is made of at the molecular level but the promise that it would yield a full understanding of organisms, their health and behavior, has not yet been realized. According to Capra:

> While biologists know the precise structure of a few genes, they know little of the ways in which genes communicate and cooperate in the development of an organism. In other words, they know the alphabet of the genetic code but have almost no idea of its syntax. It is now apparent that most of the DNA – perhaps as much as ninety-five percent – may be used for integrative activities about which biologists are likely to remain ignorant as long as they adhere to mechanistic models.
>
> (1996, p. 77)

It appears that complex biological behavior actually emerges from the interactions arising in networks of multiple genes connected through numerous feedback loops. To take an example, the causes of cancer and heart disease cannot be attributed to just one, or even a few malfunctioning genes. As Strohman, writing in 1997, explains: "In the case of coronary heart disease, there are more than 100 genes identified as having some interactive contribution" (quoted in Capra and Luisi 2014, p. 324). The late twentieth and early twenty-first centuries have, therefore, heard new calls for respect to be given to the whole organism. Goodwin (1994), in his early career an austere mathematical biologist, argues for a more holistic approach in which organisms are seen as irreducible wholes giving rise to structures that cannot be understood simply in terms of genes. The distinguished physiologist Denis Noble has argued that because there are feedbacks between different levels of organization, there is downward as well as upward causality governing the way genes operate, and has championed the cause of "systems` biology":

> It's difficult to define precisely .... But if you look at molecular biology as breaking Humpty Dumpty into as many pieces as possible, then systems biology is about trying to put him back together again. And that's actually a great deal more difficult. It's about recognizing that every physical component is part of a system and that everything interacts.
>
> (2008)

Welcoming a report on systems biology from the Royal Academy of Engineering and the Academy of Medical Sciences, he argues that:

> Combinatorial explosion means that a fully bottom-up understanding of life will probably always elude us. This is where systems biology and the merger of engineering and biology come in. The study of the interactions between the components of a system – rather than the components themselves – can be pursued at all levels of biological organization, from gene-protein networks up to the whole organism. A basic principle of engineering is central: investigate the principles of organization at each chosen level using the tools appropriate to that level.
>
> (Noble 2007)

One biological theory that rejects genetic and environmental determinism, and places organisms at the center of the stage as active players, is the theory of *autopoiesis* developed by Maturana and Varela. The term *autopoiesis* derives from the ancient Greek for "self-making." Maturana and Varela argue that, in order to answer the question "what is life?," biologists must concentrate on the circular processes through which organisms ensure their own continued self-maintenance. In their view, living beings are self-producing systems constituted by a network of biochemical production processes in which the components involved interact to produce the network, which in turn produces them. At the same time, these processes create a boundary that defines the system in relationship to its environment and is essential to the maintenance of the mutual interactions that produce the system:

> … the autopoietic organization is defined as a unity by a network of components which (1) participate recursively in the same network of productions of components which produced these components, and (2) realize the network of productions as a unity in the space in which the components exist.
>
> (Varela et al. 1974, p. 188)

It may seem that autopoiesis is a theory of closed systems. This is not the case. According to Maturana and Varela (1992), autopoietic systems have both "organization" and "structure." Organization denotes those relations that must exist among the components of a system for it to be of a particular class. This must remain invariant if the living system is to maintain its identity. Its structure, however, defined as the physical form the components and relations actually take in a particular unity, can change without the system ceasing to exist. In other words, two unities of the same class must have the same organization but may have different structures. The fact that the structure can change allows the system to build relationships with its environment. Although it is organizationally closed, it is structurally open to exchanges of energy and matter. Maturana concludes that "a dynamic composite unity is a composite unity in continuous structural change with conservation of organization" (1987, p. 335). Even in terms of change of structure, however, autopoietic systems are structure-determined rather than externally determined systems. This means that the nature of any change is determined internally by the current structure of the unity, itself the result of a history of previous structural changes, and not by an "independent external agent":

> … an external agent that interacts with a composite unity only triggers in it a structural change … nothing external to them can specify what happens to them …. It follows from this that composite unities are structure determined systems in the sense that everything is determined by their structure.
>
> (Maturana 1987, pp. 335–336)

Living systems are autonomous in the sense that it is their own organization and structure that ultimately determine their behavior. The environment can only disturb them. It is the systems themselves that "decide" what structural changes, if any, take place. This leads to a very different account of system–environment relations to that prevalent in open systems theory, where the environment is seen as dominant. Maturana and Varela's account is known as "structural coupling." Even though they are organizationally closed and structure-determined, autopoietic systems must establish appropriate relationships with their environments to ensure access to those elements that permit the processes of production of components to take place. The environment, as we know, cannot direct or specify changes in the unity. Nevertheless, it does "trigger" events that bring about structure-determined changes. On this basis, the interactions between the organism and its medium can achieve some stability over time. If this occurs, the unity and its environment become "structurally coupled," mutually influencing one another, and the unity can preserve its identity. Two organisms can also become structurally coupled, in which case

> ... the result ... is a consensual domain, that is, a domain of behavior in which the structurally determined changes of state of the coupled organisms correspond to each other in interlocked sequences.
>
> (Maturana 1975, p. 326)

There is another aspect to the theory of autopoiesis, which is equally challenging to traditional ways of thinking. For Maturana and Varela, living systems are identical to cognitive systems and so cognition itself can be explained using the same theory. Because autopoietic systems are structurally determined, and have an invariant organization, they decide not just how they will react to environmental perturbations but also what perturbations they notice and respond to. They are involved in creating their environments and, as they become structurally coupled with them, they come to know them. This is well put by Capra:

> The structural changes in the system constitute acts of cognition. By specifying which perturbations from the environment trigger its changes, the system 'brings forth a world', as Maturana and Varela put it. Cognition, then, is not a representation of an independently existing world, but rather a continual *bringing forth of a world* through the process of living. The interactions of a living system with its environment are cognitive interactions, and the process of living itself is a process of cognition. In the words of Maturana and Varela, 'to live is to know'.
>
> (1996, p. 260)

Maturana, with Lettvin, McCulloch, and Pitts, had conducted early work on "what the frog's eye tells the frog's brain," and this convinced him that living systems have no direct access to an independent external world. They can only see and respond to what is made available to them by the self-organizing and self-referential nervous systems they have developed through their biological evolution in interaction with their environments. Frogs do not see flies, rather they recognize patterns of moving shadows, which enable them to catch flies. The theory of autopoiesis, developed with Varela, provides a rigorous working through of this early thinking. He was able, with confidence, to extend his conclusions to all living systems. Because of the process of circular organization, living systems, even without nervous requires a multidisciplinary approach, he believed, and he encouraged just this among fellow scientists. Once a set of ideas was found useful in one discipline, like the life sciences, he was convinced that they could profitably be employed elsewhere. He believed that his systems perspective had something to say about language, the universe, and "global patterns" in which colonialism, slavery, and economics are all linked. His *magnum opus, Cosmos: A Sketch of the Physical Description of the Universe* (first volume published in 1845), strove to present a unified view of the universe as an ordered system just at a time when other scientists were retreating into their separate disciplines.

von Humboldt's exhilarating work set ecology along a systemic path. The next important step was the combination of von Humboldt's conception of nature as an interconnected whole with Darwin's theory of natural selection; the theory that finally provided a nonteleological explanation of the evolution of new life forms. This achievement was due to the zoologist Haeckel and announced in his *General Morphology of Organisms* (1866). In that book, Haeckel named his field of study "ecology" (the first use of the term) from the Greek word *oikos*, meaning household. Its task was to study the co-operating and conflicting relationships between the constituents of nature's household, as you might a family occupying a single dwelling. In Wulf's words:

> Haeckel took Humboldt's idea of nature as a unified whole made up of complex interrelationships and gave it a name. Ecology, Haeckel said, was the 'science of the relationships of an organism with its environment'.
>
> (2015, p. 307)

Like von Humboldt, Haeckel was inspired by the beauty and vitality of natural forces and by the interdependence of the human mind and the cosmos. His *Art Forms in Nature* (published between 1899 and 1904) heavily influenced the *Art Nouveau* style, encouraging the use of natural forms and motifs in urban settings. He became an adherent of "monism" arguing, in particular, that the organic and inorganic worlds could not be separated.

The most significant development in twentieth-century ecology has been the formulation of the concept of an "ecosystem." The word was first used by the botanist Tansley, in 1935, to refer to communities of living organisms and their physical environments (air, water, soil, etc.) interacting as a system. This idea was popularized and further developed by the brothers E. P. Odum and H. T. Odum (see Ramage and Shipp 2009). The Odums were determined to find a means of understanding the networks of interaction that gave rise to the complex behavior of ecosystems. E. P. Odum's *Fundamentals of Ecology* (1953) was a popular textbook, which introduced flow diagrams as a means of charting interrelationships in ecosystems. H. T. Odum's *Systems Ecology: An Introduction* (1983) was able to make use of what by then were established concepts in general systems theory and cybernetics (see Chapters 5 and 6). von Bertalanffy's theory of open systems provided him with the insight that ecosystems could best be viewed in terms of the transfer and transformation of energy in the system. Cybernetics suggested that these energy flows could give rise to control mechanisms through the interplay of feedback loops. In taking this perspective, he was aware that he was using a "macroscope" rather than a microscope:

> Bit by bit the machinery of the macroscope is evolving in various sciences .... Whereas men used to search among the parts to find mechanistic explanations, the macroscopic view is the reverse. Men, already having a clear view of the parts in their fantastically complex detail, must somehow get away, rise above, step back, group parts, simplify concepts, interpose frosted glass, and thus somehow see the big patterns.
>
> (H. T. Odum, quoted in Ramage and Shipp 2009, p. 89)

The Odums continued to keep up-to-date with the latest developments in systems and complexity theory and E. P. Odum, citing Prigogine on "dissipative structures"(see Section 7.3) in 1992, saw an ecosystem as "a thermodynamically open, far from equilibrium, system" (quoted in Ramage and Shipp 2009, p. 90).

When von Humboldt described the Earth as "a natural whole animated and moved by inward forces" (quoted in Wulf 2015, p. 7), he was anticipating, by more than a century, another significant development in the life sciences: the *Gaia* hypothesis that the Earth itself is a living system. James Lovelock's theory, named in honor of the Greek goddess of the earth, was conceived when he was helping NASA with the design of instruments to detect life on Mars. He reasoned that the impact of any life should be traceable in the atmosphere; just as the gases produced by plants (especially oxygen) and other organisms are obvious in the Earth's atmosphere. Extending this insight, Lovelock began to see all the organisms and inorganic elements of earth and its atmosphere as closely integrated, through feedback loops, in a self-regulating system. A moment of inspiration led him to entertain a remarkable possibility:

> The Earth's atmosphere was an extraordinary and unstable mixture of gases, yet I knew that it was constant in composition over quite long periods of time. Could it be that life on Earth not only made the atmosphere, but also regulated it – keeping it at a constant composition, and at a level favorable for organisms?
>
> (Lovelock, quoted in Capra 1996, p. 102)

While the hypothesis was attractive to romantics who, by now, had seen pictures taken from space of the beautiful blue and white globe that is Earth, it was too much for the natural scientists. When they took notice at all, they condemned it as teleological. How could natural processes be shaped by the purpose of preserving life?: "Are there committee meetings of species to negotiate next year's temperature?" (quoted in Capra 1996, p. 107). There is evidence for the hypothesis, however. The heat of the sun has increased by 25% since the beginnings of life on Earth, but the temperature on the surface has remained reasonably stable and suitable for life. With the help of the microbiologist Lynn Margulis, Lovelock began to turn his hypothesis into a theory by identifying the exact nature of the complex feedback loops, involving both organisms and inorganic matter, which enable the Earth to regulate temperature, the oxygen in the atmosphere, the salinity of the oceans – all those variables essential for maintaining the conditions for life. The planetary system, he demonstrated, was an evolving, self-regulating system in which life, at the very least, has an important role to play in creating the conditions for its own existence. Life is in no way as passive as Darwin painted it. To the charge of teleology Lovelock and a colleague, Andrew Watson, responded by producing, a computer simulation of a simple Gaia system, called *Daisyworld*, which in Capra and Luisi's opinion makes it

> … absolutely clear that temperature regulation is an emergent property of the system that arises automatically, without any purposeful action, as a consequence of feedback loops between the planet's organisms and their environment.
>
> (2014, p. 165.)

The Gaia theory has given rise to the subdiscipline of "Earth System Science" and aspects of it are sufficiently rigorous to permit experimental testing. Nevertheless, controversy remains. It appears mystical to regard the Earth itself as a living organism and even more so if, as some argue, it is viewed as capable of consciously taking decisions to make conditions appropriate for life forms. So, how does this thinking stand up when confronted by the theory of autopoiesis, the standard for "life" provided by Maturana and Varela? The components of the Earth system, as we have seen, are tightly coupled to a distinct boundary, the atmosphere, and Margulis is happy that "the planetary patina – including ourselves – is autopoietic" (quoted in Capra and Luisi 2014, p. 351.). But the production processes whereby the planet replaces organisms and its inorganic components (of oceans, soil, and air) do differ from those that take place in cellular networks, if only in the extremely long timescales involved. It is safest to regard the planetary system not as literally "living" but as a complex network of components, some living some not, which is capable of self-regulation because of the interacting feedback loops in which those components are involved.

The idea that other, more restricted ecosystems are "alive" has, of course, a long history. Paul Kingsnorth describes the Lani of West Papua as seeing the rainforest as a great being to whom they sang and which could sing back. For him:

> That the world is a machine is one story; that the world is alive and aware is another. The latter story has probably been taken for granted by the majority of human societies throughout history. The former has only really taken root in ours: post-Enlightenment, industrial western culture. The results of it – climate change, mass extinction, factory farming – should be enough to make us wonder if this story is badly constructed, badly told, or just plain wrong.
>
> (2016)

Kingsnorth has sought, in two powerful novels (2015, 2017), to reorientate our thinking so that the landscape is regarded as a character, an actor in human affairs. This perspective on nature has recently received a boost from scientific work on plant and tree communication. Brooks (2016) summarizes the argument put forward by Wohlleben, in his 2015 book *The Hidden Life of Trees*, to the effect that trees are essentially social beings communicating through a variety of olfactory, visual, and chemical impulses. In particular, they use the *mycelia*, huge underground fungal networks, dubbed the "wood-wide web," linking their roots to generate a kind of "collective fungal consciousness." This is employed by plants and trees to warn of predators, to show care for each other, to protect their young, and to support their sick or dying brethren. Certain species, however, are not quite as co-operative as others. There has been some formal recognition of this thinking in, for example, the decision in New Zealand to grant "all the rights, duties, and liabilities of a legal person" to the Te Urewera National Park and the Whanganui River and its tributaries. The theory of autopoiesis may give us pause when considering whether ecosystems are actually "alive," principally because their boundaries do not seem sufficiently fixed. Nevertheless, it remains clear that one of humanity's most pressing problems is how long ecosystems, and indeed the planet itself, can remain self-regulating in a manner suitable for life under the unique pressures placed on them by the human race.

The Kogi people, living in seclusion deep in Colombia's Sierra Nevada de Santa Marta mountains, have twice now, in 1990 and 2013, made deliberate contact with the outside world. The reason was to warn their "Younger Brothers," the people of the industrialized world, that their exploitation, devastation, and plundering of "The Great Mother," on whom we all depend, will result in our destruction. Perhaps, the scientists are at last catching up. It has been proposed that we have entered a new geological epoch, "The Anthropocene," which is distinguished by the increasingly dominant impact that human activity is having upon the Earth's geology, ecosystems, and atmosphere. In order for a new geological epoch to be defined, there must be a signal, occurring globally, that will be identifiable in deposits in the future geological record. There are many candidates including radioactive elements, carbon emissions, plastic pollution, aluminum and concrete particles, and nitrogen and phosphate residues in soils stemming from artificial fertilizers. Chris Rapley, a climate scientist, says:

> The Anthropocene marks a new period in which our collective activities dominate the planetary machinery. Since the planet is our life support system – we are essentially the crew of a largish spaceship – interference with its functioning at this level and on this scale is highly significant. If you or I were crew on a smaller spacecraft, it would be unthinkable to interfere with the systems that provide us with air, water, fodder, and climate control. The shift into the Anthropocene tells us that we are playing with fire, a potentially reckless mode of behavior which we are likely to come to regret unless we get a grip on the situation.
>
> (2016)

There was, according to Rob Cowen, “a belief among certain Native Americans that the cry of the owl was its mournful remembrance of a golden age when men and nature lived in harmony” (2015, p. 71). We will need to listen carefully. The human impact on biodiversity, climate, drainage, deforestation, and the increase in pollution will test Gaia to the ultimate over the coming decades.

3.4 Conclusion

In this chapter, we have drawn heavily on the excellent books by Capra (1996) and Capra and Luisi (2014). These authors believe that, if we are to tackle the massive problems confronting humankind, we need a new vision of reality that has life at its center. This paradigm shift in science, at its deepest level, involves “a perceptual shift from physics to the life sciences” (Capra and Luisi 2014, p. 15). Benefitting from the new understanding that has been obtained of ecosystems as autopoietic networks and dissipative structures, we can achieve and act on the basis of what Capra calls a “deep ecological awareness.” Drawing on a distinction first made by Arne Naess, he defines “shallow ecology” as human-centered, placing humans as above or outside nature. Deep ecology, by contrast, sees the world

> … as a network of phenomena that are fundamentally interconnected and interdependent. Deep ecology recognizes the intrinsic value of all living beings and views humans as just one particular strand in the web of life.
>
> (Capra 1996, p. 7)

On the basis of five principles that he sees as forming the pattern and structure of ecological systems, Capra (1996, pp. 290–295) is led to propose new social arrangements, which will promote “maximum sustainability.” The first of these principles is “interdependence.” We have to understand that each element of an ecosystem is interrelated with others in an extremely complex network of relationships. Human communities also need to nourish the multiple, mutual relationships between members. The second principle relates to the “cyclical nature” of ecological processes. Waste from one species is food for another and so there is no waste in the whole. This is seen as offering an extremely valuable lesson to human communities and should lead us to question the current way businesses interact and the economy functions. The third principle stems from the sun being the primary source of “energy flow” to ecosystems. This indicates that solar energy is the only form of energy that can maintain our human communities without pollution and that to ignore this would be disastrous. A fourth principle builds on the “co-operation and partnership” that are fundamental to ecosystems because each element within the web of life contributes to the sustenance of the whole. In human communities, co-operation and partnership have become subordinated to values of competition, expansion, and domination. Taking a lesson from ecology will help us value co-operation and partnership more highly and help conservation of the entire community. Finally, we should recognize that ecosystems are “flexible” and encompass “diversity,”

4
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We build scientific theories to organize and manipulate the world, to reduce phenomena into manageable units. Science is based on reproducibility and manufactured objectivity. As strong as that makes its ability to generate claims about matter and energy, it also makes scientific knowledge inapplicable to the existential, visceral nature of human life, which is unique and subjective and unpredictable …

(Kalanithi 2016, pp. 169–170)

4.1 Introduction

The most reductionist of the social sciences is orthodox economics, which has, for much of its life, sought scientific respectability by trying to emulate physics. The elementary unit of neoclassical economics is the “econ” (Thaler 2015), a travesty of a human being portrayed as a mathematical calculator, possessing perfect information and always seeking to optimize utility regardless of how others might think and behave. The actions of such “econs” are as determined and predictable as matter and can be incorporated into abstract mathematical models of the economy, as a mechanical system, in which a few variables can be identified and used to describe and predict behavior. The failure of orthodox economics to predict the financial crash of 2008 led Andrew Haldane, chief economist of the Bank of England, to admit: “It's a fair cop to say that the profession is to some degree in crisis.” Attempts are, in fact, being made in “behavioral economics” to pay greater attention to humans as they actually are. Go too far in this direction, however, and economics ceases to be economics as it enters the territory of competitor social sciences such as psychology and sociology. Better for economists to remain economists but be much more self-reflective about the limitations of the approach they use.

By contrast, psychology, at least when pursued as a social science, has been readier to embrace holism. Sigmund Freud, the father of psychoanalysis, saw the human personality as an energy system, comprised of the *id, ego,* and *super ego*, which had to be brought into a harmonious balance to achieve psychological well-being. More significant, for the later development of systems thinking, was the work of the *Gestalt* psychologists. Koffka, Wertheimer, and Koehler, writing in the early twentieth century, reacted against the atomistic psychology of the time, which linked particular sensations to particular physical stimuli, and sought to understand the holistic processes whereby the mind is able to bring order to the chaos of the reality with which it is confronted. There are links to Kant and Husserl and similarities with pragmatist philosophy. The German word *Gestalt*, meaning shape or form, refers to the patterns employed by the mind to organize what is perceived. In Koffka's words, “the whole is something else than the sum of its parts” (quoted in Ramage and Shipp 2009, p. 260) and Gestalt theorists deem the patterns more important than the individual elements. When we apprehend a set of dots, it is some pattern to the arrangement of dots that we see before the individual marks. Eventually, the innate laws used by the mind to generate wholes were categorized into a number of gestalt laws of perceptual organization. Koehler insisted that, on this basis, Gestalt theory could be generalized beyond psychology to philosophy, the arts, and the sciences.

Nothing more will be said about economics or psychology. In this chapter, the focus of attention is on social theory and, when helpful, on organizational analysis. There are two reasons for this. Firstly, social and organizational theorists are divided into warring factions in terms of their understanding of the nature of social reality. In Kuhn's terms (see Section 2.4), they inhabit incompatible “paradigms.” Moreover, whereas in the physical sciences, it is reasonable to regard Newton's physics as replacing Aristotle's and, in turn, being replaced by Einstein's, paradigms in sociology continue to co-exist as rival interpretations. Different systems approaches embrace these competing paradigms and we need to understand the impact this has on them. Secondly, some social theorists confronting human subjectivity, a level of complexity beyond even the life sciences, have responded by developing radically different methods of enquiry, which they regard as more appropriate than the scientific method for the social domain. Certain systems thinkers hoping to apply their insights to management have done the same. It is, therefore, social and organizational theory that can provide most insight into the different systems methodologies considered in Part III.

In exploring different sociological paradigms, we begin with Dawe's (1970) distinction between the “sociology of social systems” (called below “functionalism”) and the “sociology of social action” (called below “interpretive social theory”). Concepts such as conflict, critique, and power are then introduced through consideration of the “sociology of radical change.” There are further sections on postmodernism and poststructuralism, “integrationist social theory,” Luhmann's highly original “social systems theory,” and action research. The broad categories are indicative only and variations are explained as they arise.

4.2 Functionalism

According to Burrell and Morgan (1979), the functionalist paradigm in social theory regards social reality as having a hard, objective existence and of consisting of systems and structures that determine the behavior of individuals. For this reason, social reality is amenable to the usual methods of the natural sciences. It is observed for evidence of regularities and scientific tests are employed to establish causal relationships. The main purpose of functionalism is to understand how social order is maintained.

The French philosopher Auguste Comte was the first to argue for “sociology” as a new science, calling it initially "social physics." He was writing in the early nineteenth century. His search for patterns in the way society behaved anticipated later developments in the functionalist paradigm and, in setting out his doctrine of "positivism," he provided it with an epistemology and methodology. Positivism privileges scientific knowledge and seeks out general laws in the natural and social world, emphasizing empirical observation and quantification. Following on from Comte's work, the functionalist paradigm developed in two directions, one favoring a mechanical-equilibrium model of how order is maintained and the other taking an organismic perspective on the issue.

Vilfredo Pareto (1848–1923) was the originator of the first variant. In Aron's words, he used "a simplified model comparable to the simplified model of rational mechanics" (1967, p. 174) to explain society as a system in equilibrium. A number of key variables in a state of mutual dependence determine the movement of society. At the surface, significant change may appear to take place as different elite groups succeed one another in power. These changes are, however, merely the result of temporary fluctuations in the relationships between the key variables. Equilibrium will reassert itself sooner or later and so social stability is maintained. Of particular significance in diffusing Pareto's ideas in the United States was the biochemist L.J. Henderson, who worked alongside the physiologist Cannon (see Section 3.2) at Harvard. From his Harvard base, Henderson created a "Pareto Circle," which involved and heavily influenced thinkers such as Parsons, Roethlisberger, Barnard, and Miller, to mention only those considered elsewhere in this book. According to Henderson (1970, originally 1938–1942), the components of social systems, together with their properties and relations, exist in a "state of flux." The connections and constraints resulting from the interactions between them ensure, however, that equilibrium always reasserts itself and stability is maintained in the long run. Even if they are disturbed from outside they are, rather like a boxer's punch-ball, able to return to their original states.

The central figures in developing the organismic perspective in sociology were Spencer (1820–1903) and Durkheim (1858–1917). Drawing on an analogy with biological systems, they reasoned that society was a complex system made up of interconnected parts functioning in ways that contribute to the maintenance of the whole. Such systems are capable of adapting in response to environmental and other changes. Spencer (1969), writing at about the same time as Darwin, was interested in how societies as a whole evolve. In order to be successful in adapting to their environments, and therefore to survive in the long term, they need specific characteristics. The "survival of the fittest" ensures that only those societies that develop such characteristics prosper. Too much government regulation, in his view, hinders a society in the battle of the "survival of the fittest." Spencer also exploited, at every opportunity, the comparison between parts of a society and organs in the body. In Durkheim's sociology, social order is the most important functional prerequisite of society and has to be supported by appropriate forms of the division of labor, by other structural elements, and by shared societal values (Durkheim 1933). His focus was on "social facts" operating at the societal level, which constrained individuals and could be linked causally to other social facts using the positivist method (Durkheim 1938). Thus suicide rates are seen, by Durkheim, not as a phenomenon related to individual psychology but as generated by forms of social control and cohesion. From sociology, the organismic analogy passed into anthropology and was given coherent theoretical expression by Malinowski and Radcliffe-Brown as "structural-functionalism" (Craib 1992). The recurrent activities in a society, its structures, function to meet the survival needs of that society.

In the 1940s and 1950s, one version of sociological systems theory came to dominate American sociology. This was Talcott Parsons' "equilibrium-function model," as Buckley (1967) names it. This comprehensive model is an attempt to combine the mechanical-equilibrium model, structural-functionalism and, drawn from Weber (see next section), the idea that social systems are made up of the actions of individuals. In practice, in Parsons' theory, individual action is so circumscribed by the structures people inhabit that it is the two analogies we have been considering to date that hold center stage. As Craib puts it:

> Parsons sees a social system of action as having needs which must be met if it is to survive, and a number of parts which function to meet those needs. All living systems are seen as tending towards equilibrium, a stable and balanced relationship between the different parts, and maintaining themselves separately from other systems.
>
> (1992, p. 39)

The most famous aspect of Parsons' equilibrium-function model is his elaboration, with Smelser (1956), of the four functional imperatives that must be adequately fulfilled for a system by its subsystems if it is to continue to exist. The first letters of these four imperatives, adaptation, goal attainment, integration, and latency (or pattern maintenance), make up the well-known AGIL mnemonic. Due to the recursive character of systems, this AGIL scheme can be employed to analyze and link the various levels of system – from the societal to the organizational to the individual personality system. The meaning of the terms that make up AGIL is as follows:

A = Adaptation: the system has to establish relationships between itself and its external environment

G = Goal attainment: goals have to be defined and resources mobilized and managed in pursuit of those goals

I = Integration: the system has to have a means of coordinating its efforts

L = Latency (or pattern maintenance): the first three prerequisites for organizational survival have to be solved with the minimum of strain and tension by ensuring that organizational "actors" are motivated to act in the appropriate manner

The elegance of Parsons' thinking can best be grasped if we turn to his study of organizations. The defining characteristic of formal organizations for Parsons (1956) is their primacy of orientation to the attainment of a specific goal. The goals of organizations can, following the functionalist logic, be directly related to the needs of the wider society and organizations classified on that basis. So there are:

- Economic organizations, like business firms, oriented to the adaptive function
- Political organizations, like government departments, oriented to the goal-attainment function
- Integrative organizations, like those of the legal profession, oriented to the integrative function
- Latency organizations, like churches and schools, oriented to the pattern maintenance function

In organizations, as in society, order is maintained by a value system that inculcates shared norms among participants. To ensure harmony, organizational values have to be congruent with the central value system of society internalized by individuals during the socialization process, e.g. education. Equilibrium should then be assured since organizations can legitimate themselves in their members' eyes in terms of the function they perform for society. The main source of strain occurs if the central value system of society begins to change. In such circumstances, there is "moving equilibrium" and organizations must adapt in the direction of a new type of stability.

Finally, on Parsons' thinking, he sees the management task in organizations as differing depending upon at which of three levels it operates. At the "technical system level" it is concerned directly with the transformation process; at the "managerial level" with integrating technical-level activities and mediating between these; and at the "institutional level" it integrates the organization with the wider community it is supposed to serve (Parsons 1960).

In the 1960s, "the times they were a changing" and Parsons' work became deeply unpopular. In that radical decade, it was seen as placing too much emphasis on social order and, therefore, as unable to explain conflict and social change. The "Students for a Democratic Society" organization in the United States recognized their enemy, and Parsons' influence, in their "Port Huron Statement" of 1962:

> The vast majority of our people regard the temporary equilibriums of our society and world as eternally-functional parts.
>
> (Quoted in Bell 2013, loc. 3892)

Parsons' reward for lecturing to an audience at the London School of Economics was to be surrounded by naked young women carrying placards bearing women's liberation slogans (Hamilton 1983).

explained using the natural scientific method. Instead, he regarded human behavior as unpredictable and unique to individuals and wanted to ground the human sciences on "hermeneutics," the theory of interpretation, which he felt he could use to grasp the motivations that drive social action. The method of *verstehen*, or empathetic understanding, is recommended as a means of gaining insight into human intentions and how they give rise, through a process of "objectification," to cultural artifacts. This requires continuously going round "the hermeneutic circle" and gaining increased understanding of the relationship between the parts and wholes that constitute social reality (Checkland 1981). Dilthey also introduced the concept of *Weltanschauung* into social theory. *Weltanshauungen* are world-images constructed on the basis of our views of the world, our evaluation of life, and our ideals. Common types tend to recur and are therefore significantly implicated in objectification.

If Dilthey established that there was an interpretive option, Max Weber (1864–1920) forced sociology, through his wide-ranging and influential *oeuvre*, to take it seriously. Rather than using "system" and "structure" as starting points, he argued, sociology should be based upon the study of social action:

> Sociology ... is a science which attempts the interpretive understanding of social action in order thereby to arrive at a causal explanation of its cause and effects .... Action is social in so far as, by virtue of the subjective meaning attached to it by the acting individual (or individuals), it takes account of the behaviour of others and is thereby oriented in its course.
>
> (Weber 1964, p. 88)

The possibility of interpretively understanding the subjective meaning behind social action gives students of society, Weber thought, an advantage over those working in the natural sciences because the latter can have only external knowledge of their subject matter. To model sociology on the natural sciences to the exclusion of this "inner-understanding" or *verstehen* can only impoverish it. That said "meaningfully adequate" interpretations of social action, as the quote above implies, need to be complemented by considerations of "causal adequacy." Weber (1949) thought that the gap between the two forms of inquiry could be bridged by using "ideal-types." Ideal-types are not "ideal" in the utopian sense nor are they descriptions of reality. They are theoretical constructs that offer a "one-sided," accentuated view of a portion of reality that is both adequate at the level of meaning, in that it embodies possible forms of action, and can also be incorporated into cause–effect explanations. Weber's work is full of examples of ideal-types, for example, bureaucracy, Calvinism, feudalism, capitalism. Again, they are not descriptions of reality but precisely and unambiguously defined constructs that can be compared to reality in order to establish its similarities and divergencies.

The "phenomenological sociology" of Alfred Schutz (1899–1959) can be seen as a synthesis of the work of Weber and of Husserl, the philosophical originator of phenomenology (see Section 1.5). Schutz felt that Weber had not stated clearly enough the essential characteristics of *verstehen*, or of subjective meaning or, indeed, of action, and sought to use the phenomenological method to bring clarity to these concepts by closely interrogating people's immediate experiences of daily life and the common-sense knowledge with which they operate. Craib summarizes:

> He attempted to show how we build our knowledge of the world from a basic stream of incoherent and meaningless experience. We do this through a process of 'typification', which involves building up classes of experience through similarity .... Action and social action thus become things that happen in consciousness: we are concerned with acts of consciousness rather than action in the world, and the social world is something which we create together.
>
> (1992, p. 99)

This notion of the "social construction of reality" was popularized by Berger and Luckmann (1971), who see social reality as something that has to be constantly produced and reproduced by individuals in interaction. It might appear to exist "out-there" but it is actually an "ongoing human production." From this perspective, Durkheim's suicide rates are not "social facts" but are the result of "negotiated meanings" constructed, for example, when loved ones and officials are complicit in concealing the true cause of death in societies where a social stigma is attached to suicide (Douglas 2015). Another significant off-shoot from Schutz's thinking is "ethnomethodology." Associated particularly with the work of Garfinkel (1984), "ethnomethodology" focuses on the routine methods people employ to bring about social order. Of particular interest is the so-called "breaching experiment" where taken for granted routines are deliberately breached by the ethnomethodologist in order to reveal the work involved in this process, e.g. by acting as a stranger in your own household or cheating at board games. It will be clear that, for phenomenological sociologists and ethnomethodologists, the study of society must start from individual consciousness and understanding and from the typifications people share in constructing social reality. Indeed all that social scientists can bring are "second-order" descriptions of these primal typifications.

Our final "interpretive" tradition in sociology stems from the "symbolic interactionism" of George Herbert Mead (1863–1931). Mead is often classed, with Pierce, James, and Dewey, as one of the four key figures in American pragmatism and so the philosophical lineage of symbolic interactionism is clear. For Mead, society comes from micro-level interactions between people making judgments about what has been useful in the past and what might be in the future. Human beings have language at their disposal and this interaction can take very sophisticated forms as each agent uses vocal symbols to call forth a response in the other while, at the same time, anticipating that response. This "conversation of gestures" also allows minds to develop and self-consciousness to arise when individuals take the perspective of the other and become capable of seeing themselves as objects. Individuals are socialized when they can conceive of the attitude that their social group, the "generalised other," takes toward them and regulate their conduct accordingly (Stacey 2003, p. 322). Of course, there will be various "generalised others" available and individuals can take on many "roles" in relation to different "generalised others." Thus, mind, self, and society all emerge as a result of social processes of communication, from the bottom-up. Mead was keen that the theory of symbolic interactionism should be combined with active field work to study and address real social problems.

The occasion when the "interpretive" position in sociology challenged the hegemony of functionalism in United Kingdom organization theory can be dated precisely to 1970 and the publication of David Silverman's *The Theory of Organisations*. In this book, Silverman launched a damning critique of systems theory in its functionalist form and proposed, as an alternative for studying organizations, an "action frame of reference" derived from Weber and Schutz. This alternative was presented as an "ideal-type" constituted by seven propositions, which are summarized in Table 4.1.

Table 4.1 Silverman's ideal type of action theory.

1.	The social sciences and the natural sciences deal with entirely different types of subject matter
2.	Sociology is concerned with understanding action rather than observing behavior Action arises from meanings that define social reality
3.	Shared orientations become institutionalized and can be experienced by later generations as social facts
4.	While society defines man, man also defines society. Particular constellations of meaning have to be continually reaffirmed in everyday actions
5.	Through their interactions men can modify, change, and transform social meanings
6.	Explanations of human actions must take account of the meanings of those involved in the social construction of reality
7.	Positivistic explanations asserting that action is determined by external constraining forces are inadmissible

Source: Adapted from Silverman (1970).

As Dawe (1970) argues, there is no necessary postulate of consensus or co-operation in social action theory. In practice, however, theorists of the interpretive persuasion do seem to share with functionalists an overriding interest in how social order is constructed and maintained. This is enough for Burrell and Morgan (1979) to class the two together as constituting the "sociology of regulation" in opposition to the "sociology of radical change," which is now considered.

4.4 The Sociology of Radical Change

The sociology of radical change portrays society as divided by structural inequalities that give rise to conflict between different groups, which in turn leads to change. Any cohesion is achieved only because of the power some groups have over others. Marxism and critical theory are the most important sources for the sociology of radical change. The work of the later Marx is "objectivist" in nature seeing the contradictions that exist in society as almost inevitably provoking radical change. The work of the early Marx and the critical theorists is more "subjectivist," emphasizing the need for those suffering from the inequalities to become aware of the reality of their situation and to reshape the social system more in their own and the general interest. The job of a theorist embracing the sociology of radical change is to offer a "critique," which reveals the nature of society to the disadvantaged and provides them with the means to take action.

Marx, as is well known, turned Hegel's dialectic on its head, and saw it as operating not in the realm of thought but in history itself, specifically in the history of class struggle. As he and Engels have it, at the beginning of *The Communist Manifesto*, first published in 1848:

> The history of all hitherto existing society is the history of class struggles. Freeman and slave, patrician and plebeian, lord and serf, guild-master and journeyman, in a word, oppressor and oppressed, stood in constant opposition to one another, carried on an uninterrupted, now hidden, now open fight .... Our epoch, the epoch of the bourgeoisie, possesses, however, this distinctive feature: it has simplified the class antagonisms. Society as a whole is more and more splitting up into two great hostile camps, into two great classes directly facing each other: Bourgeoisie and Proletariat.
>
> (1967, pp. 79–80)

Marx's early writings revolve around a critique of alienated labor in capitalist society (Marx 1975a, originally 1844). Work, he argues, should be as natural to people as rest and play. However, because there is private ownership of the means of production, the owners, the bourgeoisie, are alienated by worship of money, while workers are alienated because they only involve themselves in the labor process because they are forced to in order to sustain their physical existence. They do not control the production process and the objects they make become a power over them in someone else's hands. The workers will eventually come to resent the "actuality of an inhuman existence" that they face, take over the means of production, and create a communist society. Everyone will be able to realize their essential being, creative and many-sided, through co-operative labor. In his later work, Marx's vision became less humanistic and more objectivist and determinist in nature. The three volumes of *Capital* (1961, originally 1867) seek to provide a "scientific" explanation of how the economic base of society determines its characteristics, the nature of conflict, and how change will come about. The political and ideological "superstructure" of a society is conditioned by the economic base and simply reflects the interests and ideas of the ruling class. The capitalist economic system inevitably leads to conflict between capitalists and workers because the former can only create wealth by extracting "surplus value" from the efforts of the latter. The whole system is seen as subject to increasing crises of overproduction and falls in profit. Wages are driven down and unemployment escalates. This exacerbates class conflict. Eventually the oppressed workers see through the ideologies of the ruling class, become conscious of their true interests, overthrow capitalism in a revolution, and bring a communist system into being. Althusser and Balibar (1970), much influenced by structuralism, read Marx's final writings as granting more autonomy to the superstructural "instances" such as politics, ideology, and theory. In the social totality, each instance develops unevenly, has its own contradictions and, although the economy always has the last word, can become temporarily dominant in the social formation. Revolutionary change will only occur when the contradictions in the different instances coincide. Granting some freedom to the superstructural instances is, however, at the expense of any freedom that might be attributed to human agency. Following the structuralist logic, history becomes a "process without a subject," the result of the relations between the "relatively autonomous" instances and the contradictions internal to each.

Critical Theory, associated with the Frankfurt Institute for Social Research, can be seen as a reaction to the fact that the overthrow of capitalism forecast by Marx did not occur, at least in the developed Western economies. The ultimate aim of the "Frankfurt School," which began its work in the 1920s, was still as Horkheimer put it "man's emancipation from slavery" (1976, p. 224), but a step backward seemed to be necessary in the form of a research program that accounted for the failure of Marx's prediction. The concern of Horkheimer, Adorno, and Marcuse became to explain exactly how capitalism manages to survive by means such as promoting the dominance of instrumental reason, drawing on powerful forms of socialization, colonizing culture and the mass media, and encouraging "false needs" among passive consumers. In summary, Craib argues:

> The Frankfurt theorists are concerned with the way the system dominates: with the ways it forces, manipulates, blinds or fools people into ensuring its reproduction and continuation.
>
> (1992, pp. 210–211)

The most influential modern thinker associated with the Frankfurt School is the German political philosopher, Jurgen Habermas. He is the critical theorist covered here in most depth because his work has had the closest engagement with systems thinking. However, it is broad in scope, and his conclusions have changed over time, so I have had to be selective in choosing which aspects of his thought to highlight based on what is most relevant to later discussions.

Habermas' writings are redolent of Kant and the Enlightenment in that he wants to transform and improve society by spreading the human potential for reason. Indeed, he sees the Enlightenment as an "unfinished project," in need of some correction but worthy of support and continuance. A number of important themes emerged in his inaugural lecture at the University of be rare but this does not detract from the usefulness of Habermas' conceptualization of the ideal because it can be used to unmask "systematically distorted communication" where unequal chances to participate in dialogue, deriving from an unequal distribution of power, determine that a false consensus emerges. For Habermas, therefore, progress toward a rational society is measured by the extent to which communicative competence is achieved. This in turn depends on the establishment of certain social conditions related to freedom and justice. In particular, the "public sphere" must be re-energized as an arena where democratic discussions can take place and genuine agreements can be reached.

Two remarks will be made in concluding these reflections on the "sociology of radical change." The first concerns the weakening of the binary divide between bourgeoisie and proletariat upon which Marx based his theory of class conflict in capitalist society. There have been changes in ownership patterns, with the state and pension funds now playing a significant role, and a growth in the numbers of individual shareholders. Those working for a living are a more diffuse group because of burgeoning public employment, the rise of powerful professional groups, the expansion of the middle class, the development of the service sector, the decline of heavy industry, and divisions in the working class itself. Class conflict remains and class, it can be argued, still plays a predominant role in determining life chances, but things are much more complicated than they were. Secondly, more attention is now given to other divisions and inequalities in society, which can lead to conflict and change. In 1922, Weber, while acknowledging the significance of class struggle, identified "status honor" as another source of division and conflict in society. Status honor for Weber (1948), while often coinciding with class position, arose from noneconomic qualities such as prestige, race, caste, professional groups, and religion. Different status groups arise from "the house of honor" and pursue their own lifestyles and interests, often conflicting with those of other groups. Today, gender, race, sexuality, religion, disability, and age are all recognized as sources of inequality. Sociological theories have developed that urge society to change in order to liberate oppressed groups from the social structures that have historically prevented them gaining equal access to resources, status, and power, and from participating fully in society. Varieties of feminist theory address gender oppression. Queer theory seeks to question the notion of stable sexual identities. In general, although there is a long way to go, capitalism seems able to reform itself in ways that deal with these inequalities and incorporate hitherto disadvantaged groups. This may be a sign of its progressive and liberating character or may be, as Marxists would argue, because it has more significant class inequality to protect. It remains a matter of dispute. At the level of the "world system," Wallerstein (2004) argues, inequalities continue to get worse as the dominant capitalist countries take advantage of their control of most of the world's capital and technology, and their cultural hegemony, to control trade, determine economic agreements, and set prices, thereby exploiting "peripheral" countries for raw materials and labor.

4.5 Postmodernism and Poststructuralism

Overwhelmingly, the social theorists considered so far can be seen as working in the tradition of the Enlightenment. They are committed to sweeping away the myths and prejudices that bound previous generations and using reason to understand and improve the world. They share a belief in rationality, truth, and progress. This position has been labeled by postmodernists as "modernist". Postmodernists attack the whole Enlightenment rationale and want to puncture the certainties of modernism. In doing so, they embrace a position that, if not "subjectivist," is certainly "relativist" in nature.

Lyotard, in his book *The Postmodern Condition* (1984), recognizes two major manifestations of modernism in social theory. These can be called, following Cooper and Burrell (1988), "systemic modernism" and "critical modernism." Systemic modernism, as its name suggests, is identified with the systems approach as a means of both understanding society and programming it for more effective performance. Parsons (see Section 4.2) and Luhmann (see Section 4.7) are regarded as representative theorists. In this approach, the system stands as the subject of history and progress, following its own logic to increase "performativity," in terms of input–output measures, and handle environmental uncertainty. Systemic modernism relies on the scientific method to discover what is logical and orderly about the world and to assist with prediction and control. Humanity is dragged in the wake of the system as questions about efficiency and stability replace those about truth, falsity, and justice. Critical modernism is identified with theories that seek to explain history in terms of the accumulation of learning and the progressive liberation of humanity from constraints so that it can assume mastery and take on responsibility for its own destiny. Hegel and Marx are in this category and Habermas (see Section 4.4) is seen as the archetypal contemporary representative of the approach, proposing a unified theory of knowledge linked to different human interests and aiming his whole project at human emancipation directed by universal consensus arrived at in the "ideal speech situation." Lyotard opposes all the "grand narratives" proposed by modernist thinkers. Science is, in his view, only one kind of "language game" with limited relevance to social affairs. The new physics demonstrates, as in quantum theory, that the quest for precise knowledge about systems is misguided. And the attempt to limit individual initiative to serving current system imperatives destroys exactly the novelty a system needs to adjust to its environment. Nor is it easy, in Lyotard's view, to sustain the modernist notion that language is transparent and oriented to achieving consensus. There are many language games, obeying different rules, characterized by struggle and dissension, and this is necessary to promote innovation, change, and renewal. We have, therefore, to be tolerant of differences and of multiple interpretations of the world, and we must learn to live with the incommensurable since there is no meta-theory that can reconcile or decide between different positions. Postmodernism, indeed, thrives on instability, disruption, disorder, contingency, paradox, and indeterminacy.

We now turn to the contributions of Derrida and Foucault, two of the most famous postmodern theorists (see the chapters by Hoy and Philp in Skinner 1985). Both are also commonly referred to as "poststructuralists" as their work emerged out of but then transformed the structuralist theory considered in Section 4.2. Structuralism tends to regard the underlying structures that govern surface activity as "fixed" and as having an "objective" status. Poststructuralism suggests that structures are more unstable and fluid. They condition the way we think but can give rise to multiple meanings.

Derrida accepts Saussure's conclusion that linguistic meaning derives from the structure of language itself so that, rather than simply mirroring objects, language creates objects. He goes much further, however, in embracing a relativistic position. Once the relationship between signs and what is signified in the world is broken, it appears to Derrida that it must be possible to create an infinite number of relational systems of signs from which different meanings can be derived. To take the distinctions made in any particular discourse as representative of reality is an illegitimate privileging of that discourse, which involves hiding other possible distinctions. Derrida's "deconstructive" method seeks to reveal the deceptiveness of language and the work that has to go on in any "text" to hide contradictions (which might reveal alternative readings) so that a certain unity and order can be privileged and "rationality" maintained. The shift to the study of the structure of language and away from the intentions of the speaker, as the route to discovering the meaning of "texts," puts Derrida at the forefront of the postmodernist assault on humanism. In his view, it is discourse that speaks the person and not the person who uses language. In the contemporary world, where there are many possible discourses, the idea of an integrated, self-determining individual becomes untenable. From this follows a rejection of the notion of historical progress, especially with humans at the center of it.

In his early work, Foucault conducts an "archeological" investigation of discursive formations in different human sciences, such as medicine, psychiatry, and criminology (see Philp in Skinner 1985). In his view, every field of knowledge is constituted by sets of classificatory rules, which determine whether statements are adjudged true or false in that field. The discursive formations and classificatory rules that govern a discipline will alter over time, but there is no reason to believe that the current arrangements give rise to more "objective" statements than earlier ones in the sense that they mirror reality more closely. The idea of the accumulation of knowledge is rejected by Foucault. So is the notion of a constant human subject who can autonomously engage in promoting emancipation. Individuals have their subjectivities formed by the discourses that pertain at the time of their birth and socialization. These not only structure the world but shape individuals in terms of their identity and ways of seeing. To help make this point, Foucault uses a passage from Borges:

> This passage quotes a "certain Chinese encyclopaedia" in which it is written that "animals are divided into: a. belonging to the Emperor, b. embalmed, c. tame, d. sucking pigs, e. sirens, f. fabulous, g. stray dogs, h. included in the present classification, i. frenzied, j. innumerable, k. drawn with a very fine camelhair brush, l. et cetera, m. having just broken the water pitcher, n. that from a long way off look like flies".
>
> (Foucault 1973, p. xv)

What this reveals to us, Foucault comments, is both the stark impossibility of thinking *that* and the limitations of our own system of thought.

For Foucault, discourses are not simply "free-floating" as they appear to be in Derrida. In his later writings, he emphasizes the need to study the power relations with which they are inextricably connected and gives the name "genealogy" to the accounts he offers of the power struggles involved as particular forms of discourse compete for dominance. For example, *I Pierre Riviere* (Foucault 1982) sets out the power dynamics underlying the competition between psychiatry and criminal justice to explain a brutal murder in France. Medicine was at the point of getting its own custodial institutions and it was essential, to a group of leading Paris psychiatrists, that their discourse triumphed over that of the legal establishment and that Riviere was affirmed as mad. If particular discourses come to the fore because of power relations, they also embody knowledge and, Foucault argues, knowledge offers power over others. In the modern era, the human sciences have created human "subjects" in such a way as to make them available for stricter discipline and control by society. Discourses, therefore, play a role in establishing patterns of domination, benefiting the meanings favored by some while marginalizing the voices of others. This explanation of the power/knowledge relationship, owing much to Nietzsche, is Foucault's most valuable contribution to social theory. Discourses depend upon power relationships. On the other hand, they carry power in the way they make distinctions and so open or close possibilities for social action. A claim to power can, therefore, be seen as present in any claim to knowledge. Power, understood in this way, is omnipresent in social relations. Foucault's genealogy is aimed at unmasking the pretensions of all "totalising discourses." It dismisses their claims to provide objective knowledge. In particular, it offers criticisms directed at the power/knowledge systems of the modern age and support for "subjugated knowledge." In this way, a space is opened up which makes resistance possible, albeit on a local basis in response to specific issues. By paying attention to difference at the local level, to points of continuing dissension, it become feasible to give a voice back to those silenced or marginalized by the dominant discourses.

It is worth concluding this section by referring to a series of lectures by Habermas (1987) responding to the postmodern attack on his position and elaborating a critique of various postmodernist thinkers. In each case he shows that the theorist he is critiquing has something valid to say but exaggerates it out of all proportion. Derrida concentrates on the problems that exist in using language to achieve mutual understanding. Habermas is prepared to acknowledge they exist but details all the positive aspects of language for learning and dealing with problems in the world. Foucault focuses on certain dysfunctions associated with rationalization processes in society but ignores, Habermas argues, the achievements of those same forces. In short, Habermas recognizes that postmodernists have something to say but believes that we should renew and revitalize the Enlightenment vision rather than abandon it. More reason is needed rather than less.

4.6 Integrationist Social Theory

Integrationist social theorists seek to reconcile some of the divides in sociology. They concentrate on the contrasting views that have arisen about the relative importance of "social facts" and human agency and also, sometimes, try to resolve the debate around social order and radical change. In many ways their work is an extended elaboration of Marx's famous statement, of 1852, that:

> Men make their own history, but not of their own free will; not under circumstances they themselves have chosen but under given and inherited circumstances with which they are directly confronted.
>
> (Marx 1973, p. 146)

An attempt will be made to capture the essence of the approach here.

Walter Buckley (1976) takes his inspiration from general systems theory (see Chapter 5), which he sees as an essentially "process-conscious" approach. In mechanical and organic systems, he argues, the ties linking components tend to be rigid, concrete, direct, simple, and stable. In complex adaptive systems, like organizations and societies, however:

> Transmission of energy along unchanging and physically continuous links gives way in importance to transmission of information via internally varying, discontinuous components with many more degrees of freedom.
>
> (Buckley 1976, pp. 184–185)

In these circumstances, "structure" becomes a theoretical construct used to refer to the relative stability of "underlying, ongoing micro-processes." To understand society, we need a "process" approach that concentrates on the actions and interactions of the components through which structures arise, persist, and change. Buckley calls this process of structure elaboration "morphogenesis." It is essential because complex adaptive systems can only survive by adapting their structures in response to internal and external changes. As part of the process, individuals and groups become linked in different types of "communication nets," which can form structures characterized by any of "cooperation," "competition," or "conflict." According to Buckley, his theory can balance and integrate structural and process analysis and use the same variables to explain both stability and change.

collapse into either functionalism or interpretivism.

4.7 Luhmann's Social Systems Theory

In Luhmann's (2013) view, contemporary sociology is in crisis because it remains in thrall to the "old European thought" of Durkheim, Weber, and Marx. He has no doubt that his own rigorously constructed theory of society, heavily reliant on modern systems theory and cybernetics, can provide a better alternative. This alternative is of the most far-reaching kind and challenges dominant assumptions such as that society consists of human beings and their interrelations, that it is integrated by consensus, that it consists of regional and territorially limited units, e.g. countries, and that it can be observed from the outside. His own investigations, instead, reveal the need for a transition to "... a radically antihumanist, a radically antiregionalist, and a radically constructivist concept of society" (Luhmann 2006a, p. 238).

According to Luhmann (the following account also draws upon Borch 2011; Moeller 2006, 2012), between the sixteenth and eighteenth centuries, society began to change from the stratified form of differentiation, the focus of Marxist theory, toward functional differentiation. This signaled the arrival of modernity. In contemporary society, a number of significant function systems can be identified: economy, politics, law, education, science, art, religion, sport and, a rising star, mass media. They all serve functions for society, e.g. politics promotes collectively binding decisions, but they do not coalesce into a unified whole. For Luhmann, modern society is less than the sum of its parts. Society is also "decentered" because there is no hierarchy of function systems. Further, it is also a "world society," since most of the function systems transcend geography and operate on a global basis. Society is not moving beyond functional differentiation and so the idea of postmodernity is a myth. Nevertheless, the advance of functional differentiation does require a radical change in theoretical attitude:

> If we see stratification we will tend to see ... injustice, exploitation and suppression .... If, on the other hand, we see functional differentiation, our description will point to the autonomy of the function systems .... Then, we will see a society without top and without centre; a society that evolves but cannot control itself.
>
> (Luhmann, quoted in Moeller 2012, loc. 85)

Luhmann studied under Parsons (see Section 4.2), and respects his sociology, but feels he has to break with Parsons' theory of social systems in two ways to better understand modern function systems.

First, he argues, the idea that human actors are the components of social systems, that "action is system," needs revisiting (Luhmann 2013, p. 7). Inspired by Maturana and Varela's theory of autopoiesis, Luhmann wants to find a correlate in the social domain for the biochemical circularity that produces the operationally closed systems of life. He concludes that the only possible candidate is "communication." Unlike action, communication is clearly a social operation because it "involves or implies … a simultaneous presence of at least two consciousness systems for its emergence" (Luhmann 2013, p. 211). In Luhmann's theory of social systems, therefore, communication replaces action as the basic operation that gives rise to operational closure:

> The idea of system elements must be changed from substances (individuals) to self-referential operations that can be produced only within the system and with the help of a network of the same operations (autopoiesis). For social systems in general and the system of society in particular the operation of (self-referential) communication seems to be the most appropriate candidate.
>
> (Luhmann 1989, pp. 6–7)

Communicative events make up "networks" in that they are constantly referring to previous communications and necessarily lead on to others. Mingers provides an example:

> In the law, a legal communication might be the judgement of a court. It contains a particular selection of information … is presented in a particular way … and … interpreted in particular ways. The judgement as a whole leads to further communications, both directly through its consequences and indirectly as part of case law.
>
> (1995, p. 143)

Social systems are, therefore, operationally closed systems maintained by an ongoing flow of communications.

Second, Luhmann finds it necessary to abandon the whole/parts distinction embodied in Parsons' work. To develop something better, he again draws upon Maturana and Varela's theory of autopoiesis. In the process of self-production, operationally closed systems define themselves in relationship to their environments. If they did not do so, they would be overwhelmed by complexity. Operational closure ensures that they are constituted to take notice of only a part of the environment and this makes knowledge possible for them; ironically because they are protected from having direct access to "reality." Social systems are, therefore, "cognitive systems," which, as we saw in Section 3.2, create their own reality. Different social systems will do this in different ways rather than act as parts of a whole. In Luhmann's conception, society must be considered not as a unity but in terms of "difference," especially the distinction between system and environment:

> The theory must change its direction from the unity of the social whole as a smaller unity within a larger one … to the difference of the systems of society and environment…. More exactly, the theme of sociological investigation is not the system of society, but instead the unity of the difference of the system of society and its environment.
>
> (Luhmann 1989, p. 6)

Function systems, as social systems, construct reality in different ways and each creates its own specific communicative operations exploring the broad “conditions of possibility” made available by language.

This is redolent of the thinking of von Glasersfeld, as well as Maturana and Varela, and Luhmann self-identifies as a “radical constructivist.” To refine his “difference theoretical” approach and escape the biological terminology of autopoiesis, he turns to the mathematician George Spencer-Brown, another member of the “second-order cybernetics” tradition broadly defined (see Section 6.4). Spencer-Brown declares that the theme of his book *Laws of Form*, published in 1969, “is that a universe comes into being when a space is severed or taken apart” (quoted in Borch 2011, p. 51). The act of severance leads to a distinction between the thing that is distinguished and its context; between system and environment in Luhmann's theory. Function systems are networks of communication that distinguish certain communications to which they will give intense attention while all others, being in their environments, are treated with indifference. They do this, echoes of Levi-Strauss's structuralism here, using binary codes that determine their area of interest. Thus the function of science is to generate new knowledge and it operates on the basis of the distinction true/false. It is indifferent to whether something is legal or illegal. That is the concern of law. Economics is interested in the distinction profitable/not profitable, politics in government/opposition, art in beautiful/ugly, education in good grades/bad grades, sport in winning/losing, and the mass media in information/noninformation. Once established, function systems develop programs that enable them to apply their codes correctly as with, for example, the theories and methods of science, and institutions come into being to facilitate their work. Clashes between function systems occur as, for example, when the US legal system objected, in 2018, to President Trump treating who should be admitted into the country as a political issue.

For Luhmann, therefore, highly differentiated function systems, interpreting the world according to their own logics, have largely replaced other differences, such as class, religion, race, sex, and region, as the defining feature of modern society. The Enlightenment project can be condemned to history because no “overarching reason” exists on which to base a critique of the existing order and because the power of human agency is significantly downgraded. People cannot pretend to be in a position to steer society and mold it according to their intentions. Certain positives emerge from Luhmann's new vision. The separation of function systems acts as a bulwark against totalitarianism and as a counter to totalizing discourses, which can wreck havoc in the name of universal liberation. There are also important negatives. The decentering of society makes it virtually impossible to mount a co-ordinated response to “grand societal challenges” such as climate change because the function systems see the issues differently, operate on different timescales, and can only provide partial solutions (Luhmann 1989). In his later writings, Luhmann also warns that the globalization of functional differentiation is bringing a new meta-code, of inclusion/exclusion, to the fore. Global action systems aim at all-inclusion but there are increasing numbers of people who fail to meet their requirements and individuals excluded from one function system are likely to fail the test of others:

> No education, no work, no income, no regular marriages, children with no birth certificate, no passport, no participation in politics, no access to legal advice, to the police, or to the courts – the list can be extended and it concerns, depending on the circumstances, all marginalizations up to total exclusion.
>
> (Luhmann 2006b, p. 270)

Further, groups clinging on to old identities perhaps religious, and excluded from communication by the new societal configuration, can turn to violence to assert themselves. Critics of Luhmann will, of course, continue to argue that some systems in the social whole, usually the economy, dominate others or, at least, agree with Habermas that their rationality inappropriately pervades the rest. Bourdieu offers a compelling case that stratification rather than functional differentiation continues to dominate society, with social class determining the access individuals and groups have to the rewards of the different function systems. It is indeed strange that Luhmann points to multiple exclusions at the bottom of function systems but not multiple inclusions at the top. In Owen Jones' view:

> As well as a shared mentality, the Establishment is cemented by financial links and a 'revolving door' culture: that is, powerful individuals gliding between the political, corporate and media worlds – or who manage to inhabit these various worlds at the same time.
>
> (2014, p. 6)

Although, in Luhmann's theory, systems are highly differentiated from one another – for one social system all the others are in its environment – relations do develop between them. To explain how this can occur, Luhmann again draws upon the work of Maturana and Varela, this time making use of the concept of "structural coupling." Social systems are operationally closed, and therefore develop according to their own structural logics, but they can be perturbed or "irritated" by other systems in their environments in ways that bring about structure determined changes. Over time, frequent irritations between two social systems can lead to them continuously resonating with one another and becoming "structurally coupled" in the sense that their relationship achieves some stability and they come to rely on each other. The association between the function systems of politics and economics, for example, is signaled by taxes and central banks. Both function systems retain their overall autonomy but integration leads to a reduction in the freedom each has individually.

Luhmann's social theory has provoked significant controversy. If communication constitutes the distinctive operation of social systems, as he argues, then human beings, as both living and psychic systems, are not components of social systems but in their environment (Luhmann 2013, p. 188). This conclusion has brought him grief from critics who regret that this makes his theory antihumanist. For Luhmann, however, it is an inevitable result of the shift from the old "action is system" type of sociology to the more rigorous and fruitful system/environment version. Human beings are operationally closed "psychic systems," constituted by the thoughts and feelings that go round in consciousness. Social systems can provoke thoughts and feelings in psychic systems but cannot know or determine them. This is something to welcome, Luhmann says. Surely we do not want social systems that have direct access to our minds? Social systems are also operationally closed, sustained by ongoing networks of communication. Psychic systems can irritate them but whether there is any impact, and if so what the impact is, depends entirely on the readiness of the communication system to pay attention and respond at the time. That said, Luhmann is clear that the autopoiesis of social systems does depend on the existence of living and psychic systems. For social systems to survive, a consciousness has to engage in the process of communication, paying attention to it and showing a willingness to continue it. He uses the term "interpenetration" to describe the extremely close structural coupling that exists between psychic and social systems. Mind and society share the medium of meaning and co-evolve using language as a coupling mechanism. Psychic systems provide social systems with communications they can make use of to sustain and develop themselves. Social systems provide psychic systems with things to think about and, in modern, functionally differentiated society, the opportunity to adopt multiple identities. The fact that social and psychic systems are operationally closed to each other does, however, give Luhmann pause when considering, for example, efforts by the state to reform criminals and change the attitude to work of the continuously unemployed. Social systems can "irritate" psychic systems but certainly not control the way welfare efforts are understood and received. He worries that the cost to the welfare state of trying to ensure the inclusion of all citizens impinges on the boundary with the economy and impacts its effective functioning. This argument has been read as supportive of a neoliberal agenda.

Luhmann's work is equally far-reaching when applied to social theory as to society itself. Here he takes inspiration from the founding father of second-order cybernetics, Heinz von Foerster (see Section 6.4), and again from Maturana and Varela. von Foerster complemented the original emphasis of cybernetics on observed systems of communication and control with the insight that it also needed to study "observing systems." Maturana and Varela's study of living systems led them, as we saw in Section 3.2, to the conclusion that "anything said is said by an observer." In Luhmann's view, operationally closed psychic and social systems, including social theorists and theories, are themselves "observers" and should be studied as such. Philosophers and theorists, such as Parsons, Marx, Husserl, and Habermas, seem to think that they are "first-order" observers with a grasp of social reality, which they can understand better than ordinary people and other theorists. In fact, they are simply "observers" who create the reality they theorize about using their favored distinctions, often the out-moded subject/system divide. Social theory, in Luhmann's view, must give up on ontological certainty and become the study of how first-order observers observe:

are strong on theory but are weak on practice. Social scientists rarely seem to draw out the implications of their work in terms of specific guidance for what can and should be done to improve organizations and society. The systems practitioners studied later are, by contrast, dedicated to practice but often neglect theory. It is obvious that any attempt to change social systems must rest upon assumptions, conscious, or otherwise, about the nature of social reality. If systems practitioners fail to reflect upon the theoretical assumptions they make, they deprive themselves of learning, from practice, how useful or otherwise their implicit theories are and, as a result, miss out on the opportunity offered to rethink their practice. Parts III and IV hope to demonstrate how powerful a combination social theory and systems practice can be.

One important conclusion that can immediately be drawn is that, to deal with the massive problems confronting humankind, we need more than the perceptual shift from physics to the life sciences that Capra and Luisi (2014) advocate. There is much to learn from biology and ecology, including much that the social sciences do not touch upon. Nevertheless, as this chapter demonstrates, the social sciences point to "emergent properties," which give rise to new issues that only come to the fore at the societal level of complexity. These desperately require our attention. They include:

- The need to maintain order and manage systems in which components are linked by the transmission of information rather than fixed energy links, making process at least as important as structure
- The importance of meaning and the way it influences human intentions, purposes, actions, and interactions
- The need to establish a rational consensus, or at least an accommodation, between individuals and groups with different perspectives so that decisions can be made and action can be taken
- "Social facts," or social structures, or "function systems," which may initially emerge from human action and interaction but then escape our control
- Structural inequalities, which can give rise to conflict, including issues of class, gender, race, globalization
- The exercise of power by some social groups over others and the role of power/knowledge
- Poverty and the issue of exclusion
- The way that social theories can themselves play a role in shaping the social world they describe

A further perceptual shift is needed, which embraces the lessons of the social sciences. It is the argument of Parts III and IV that systems thinking is making that shift and, in doing so, is developing in a manner that can significantly improve our chances of success in managing the enormous challenges that we face.

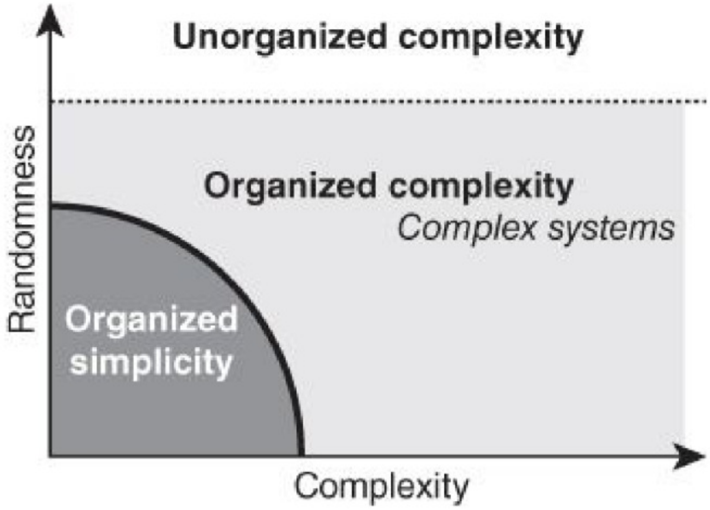
Before pursuing that argument, however, consideration must be given to the attempts made by systems thinking to establish itself as a science in its own right; as a “trans-discipline” with “organised complexity” as its subject matter. In doing so, it has sought to contribute to established disciplines in the physical, life, and social sciences and to unite the scientific endeavor for the betterment of mankind.

Part II

The Systems Sciences

> Now I want to talk about the other significant historical event which has happened in my lifetime, approximately in 1946–7. This was the growing together of a number of ideas which had developed in different places during the Second World War. We may call the aggregate of these ideas cybernetics, or communication theory, or information theory, or systems theory … . All these separate developments in different intellectual centres dealt with communicational problems, especially with the problem of what sort of a thing is an organized system
>
> (Bateson 1973, p. 450)

A paper by Weaver (2003, originally 1948) helps us to clarify the subject matter of these "systems sciences." Weaver argues that the traditional scientific method has been successful in fields characterized by quantitative and logical problems where its mathematical tools can gain purchase. In the seventeenth, eighteenth, and nineteenth centuries it was able to tackle problems of *organized simplicity* involving a very small number of objects related in predictable ways (simple, deterministic). Weinberg (2011) calls this a region of machines or mechanisms. The problems it poses yield to the classical mathematical tools of calculus and differential equations. Newtonian mechanics provides the exemplar. In the late nineteenth century, with the advent of statistical mechanics (see Section 2.2), science was able to broaden its scope to problems of *unorganized complexity* consisting of huge numbers of components exhibiting a high degree of unpredictability (complex, random). This is a region of aggregates, of gasses and populations (Weinberg 2011). It can be tamed by statistics and probability theory and the equations of thermodynamics are the exemplar. The two sets of mathematical tools are, therefore, complementary. Unfortunately, as Klir (2001) notes, they address only the extremes of the scales of complexity and randomness and the great majority of real-world problems are located somewhere in between. This is illustrated in the figure below.



Three classes of systems that require distinct mathematical tools.

Weaver comments:

> One is tempted to oversimplify, and say that scientific methodology went from one extreme to the other – from two variables to an astronomical number – and left untouched a great middle region. The importance of this middle region, moreover, does not depend primarily on the fact that the number of variables involved is moderate .... The really important characteristic ... which science has as yet little explored or conquered, lies in the fact that these problems ... show the essential feature of *organization*. In fact, one can refer to this group of problems as those of *organized complexity*.
>
> (2003, p. 380)

Organized complexity, the great yawning gap in the middle, throws up problems that are too complex for analysis and too organized for statistics. They are problems that require us to deal simultaneously with a sizeable number of factors interrelated into an "organic whole." This is the region of "systems" (Weinberg 2011) in which the traditional methods of science are simply not suitable. Weaver provides, as examples, environmental problems, the study of aging, diverse problems associated with modern technology and medicine, how currency can be wisely and effectively stabilized, how the behavior of organized groups of people can be explained, what sacrifices of present self-interest are necessary to bring about a "stable, decent and peaceful world" (Weaver 2003, p. 381).

Let us consider the 2014 Ebola outbreak in West Africa. Epidemiology has traditionally relied upon both deterministic and statistical models to make its predictions about disease spread; either seeking to categorize a population into a very small number of "compartments," and charting the linear interactions between these using differential equations, or trying to determine the average behavior of individuals and using probabilities to make calculations. Unfortunately, disease transmission systems exhibit neither organized simplicity nor unorganized complexity, and so the models have been found wanting. It was clear to Pruyt et al. (2015) that the Ebola outbreak was characterized by organized complexity and that modeling needed to be based upon a systems approach. In particular, the normal factors that might be taken into account in transmission models should be complemented with a host of psychological and sociocultural effects that play an equally significant role in "organizing" the system. To name just a few: fear-induced contact rate reduction, fear-induced increases in levels of hygiene, indigenous protocols for epidemics and burials, fear of dying in quarantine, learning and the accompanying attitude change, fleeing the region, uprisings. It is possible to add, with an awareness of Luhmann's sociology (see Section 4.7), the role that the various "observations" made by governments, the World Health Organisation (both locally and internationally), aid agencies, the media and drug companies play in creating the organized complexity.

Problems of this type, Weaver insists, which predominate in the life, behavioral, social, and environmental sciences, require

> ... science to make a third great advance, an advance that must be even greater than the ... conquest of problems of simplicity or the ... victory over problems of disorganised complexity. Science must, over the next 50 years, learn to deal with ... problems of organized complexity.
>
> (2003, p. 341)

It is this challenge that the systems sciences have embraced in the form of general systems theory, cybernetics, and complexity theory.

> … growth, regulation, hierarchical order, equifinality, progressive differentiation, progressive mechanization, progressive centralization, closed and open systems, competition, evolution toward higher organization, teleology, and goal-directedness.
>
> (Hammond 2003, p. 119)

Although, as we can see, von Bertalanffy derives many of his insights from his biological work, he believes that they can be transferred to other disciplines because the principles are not specific to biology. They are general system principles that apply to complex systems of all types, whether they are of a physical, biological, or social nature. The principle of progressive differentiation, for example, is ubiquitous in biology, psychology, and sociology. According to von Bertalanffy, GST is not just possible, it also fulfills a real and urgent need. The sciences have become increasingly specialized and scientists in different disciplines find it difficult to communicate with one another. GST can provide a much broader and better framework for the unification of disciplines than the reductionism that comes from following in the footsteps of physics. He is now able to explain the major aims of GST (von Bertalanffy 1971, p. 37):

- There is a general tendency toward integration in the various sciences, natural and social
- Such integration seems to be centered in a general theory of systems
- Such theory may be an important means of aiming at exact theory in the nonphysical fields of science
- Developing unifying principles running "vertically" through the universe of the individual sciences, this theory brings us nearer to the goal of the unity of science
- This can lead to a much-needed integration in scientific education

A main thrust of von Bertalanffy's thinking is to reject the reductionism involved in explaining biology purely in terms of physics. He is equally keen to protect the autonomy of the human and social sciences and condemns simplistic attempts to apply concepts from biology to psychological and social phenomena. These higher levels of complexity give rise to their own emergent properties. A systems-theoretical reorientation of psychology leads away from "the robot model of human behavior" toward a new image of the human being as an "active personality system," inner-rather than outer-directed, and creating its own universe:

> Emphasis [is] on the creative side of human beings, on the importance of individual differences, on aspects that are non-utilitarian and beyond the biological values of subsistence and survival – this and more is implied in the model of the active organism.
>
> (von Bertalanffy 1971, p. 204)

Once we reach the social level, a world of symbols, values, social entities, and cultures emerges. Humans are, through language, both symbol-dominated