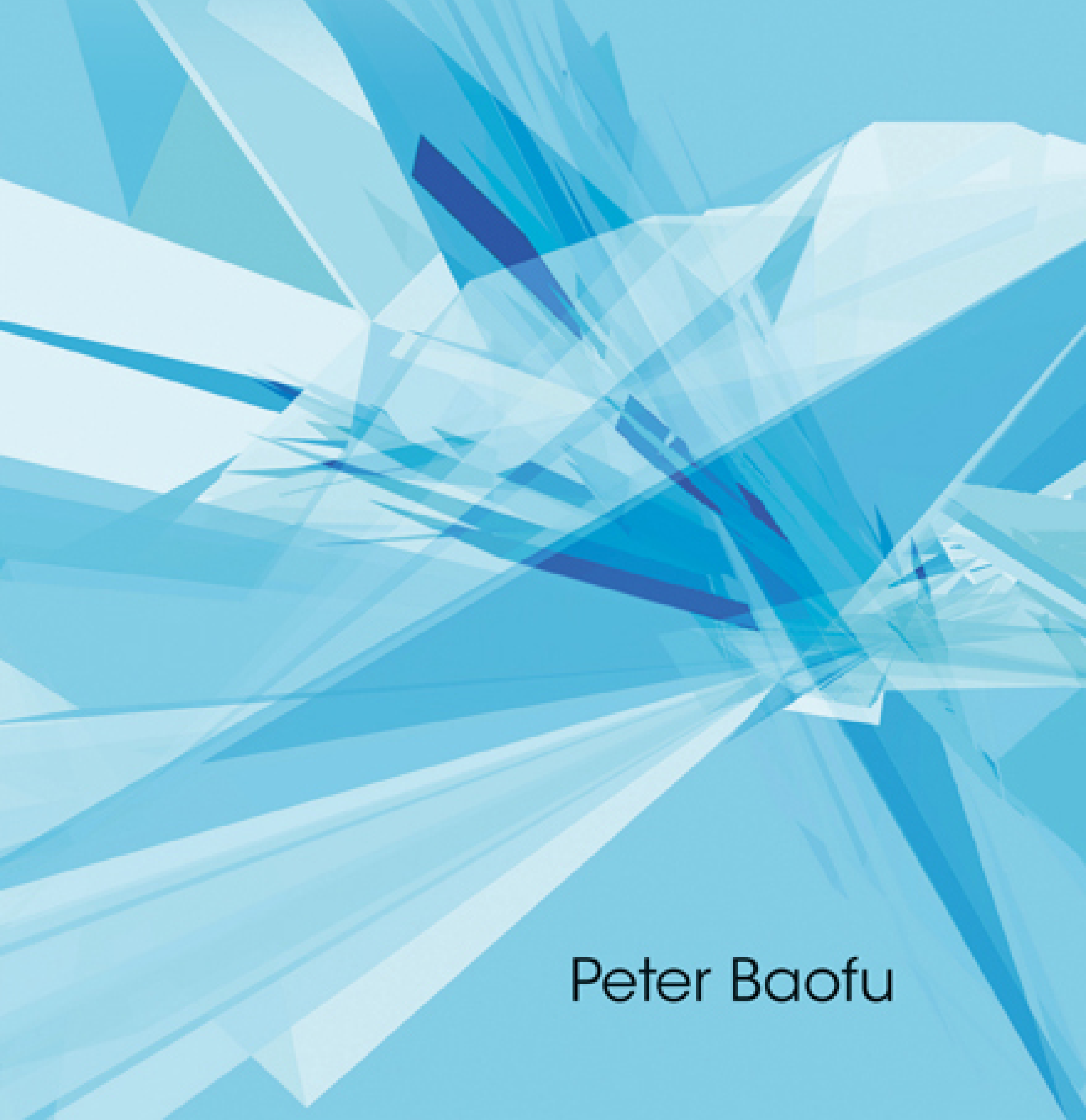
The Future of Complexity

Conceiving a Better Way to Understand Order and Chaos



Peter Baofu

THE FUTURE OF COMPLEXITY

Conceiving a Better Way to
Understand Order and Chaos

This page intentionally left blank

The Future of Complexity

Conceiving a Better Way to Understand Order and Chaos

Peter Baofu

World Scientific

NEW JERSEY • LONDON • SINGAPORE • BEIJING • SHANGHAI • HONG KONG • TAIPEI • CHENNAI

Published by

World Scientific Publishing Co. Pte. Ltd.
5 Toh Tuck Link, Singapore 596224
USA office: 27 Warren Street, Suite 401-402, Hackensack, NJ 07601
UK office: 57 Shelton Street, Covent Garden, London WC2H 9HE

British Library Cataloguing-in-Publication Data
A catalogue record for this book is available from the British Library.

THE FUTURE OF COMPLEXITY
Conceiving a Better Way to Understand Order and Chaos

ISBN-13 978-981-270-898-4
ISBN-10 981-270-898-7
ISBN-13 978-981-270-899-1 (pbk)
ISBN-10 981-270-899-5 (pbk)

Printed in Singapore.

To the Future World Beyond Complexity Theory

This page intentionally left blank

Books also by Peter Baofu

● *Beyond the World of Titans,*
and the Remaking of World Order (2007) ●

● *Beyond Nature and Nurture* (2006) ●

● *Beyond Civilization to Post-Civilization* (2006) ●

● *The Future of Post-Human Space-Time* (2006) ●

● *Beyond Capitalism to Post-Capitalism* (2005) ●

● Volume 1: *Beyond Democracy to Post-Democracy* (2004) ●

● *Volume 2: Beyond Democracy to Post-Democracy* (2004) ●

● *The Future of Post-Human Consciousness* (2004) ●

● *The Future of Capitalism and Democracy* (2002) ●

● Volume 1: *The Future of Human Civilization* (2000) ●

● Volume 2: *The Future of Human Civilization* (2000) ●

This page intentionally left blank

Contents

Part Two: Nature

Part Three: The Mind

Part Four: Society

Part Five: Culture

Part Six: Conclusion

This page intentionally left blank

Tables

This page intentionally left blank

Preface

Complexity, and its kindred notion, simplicity, are such abstract ideas that if we try to discuss them in a completely general way we are not likely to find anything worthwhile to say. These notions can be of value to us, but only after we have specified an interpretation as to what sort of item it is, the complexity and simplicity of which are to be considered, and how varying degrees of complexity and simplicity are to be estimated. Many different interpretations can be spelled out, relevant to different issues in diverse fields of study, such as metaphysics, aesthetics, logic, mathematics, and the sciences.

In the history of philosophy these abstract notions have been of considerable importance to metaphysicians. Plato suggests that the Demiurge, in creating the cosmos, intended to harmonize complexity with simplicity. Leibniz, committed to viewing ours as the best of all possible worlds, adds that, in order to be so, it must exhibit the maximum overall combination of complexity with simplicity. This will amount to great simplicity in its universal laws, together with great variety in its particular details. Kant extended this outlook into philosophical aesthetics by claiming that to experience an object as beautiful is to be aware of it as having an inexhaustible complexity of detail, combined with the greatest compatible simplicity in its formal structure.

Philosophers of science also have invoked the notions of complexity and simplicity, especially in connection with their accounts of scientific reasoning. To be sure, some of them had clung to Francis Bacon's principle of induction by simple enumeration, imagining that this could be the logical basis of all scientific method. Others, however, recognized that Bacon's principle fails to account for many important scientific inferences, such as those involved in curve-fitting. Kepler sought to find the orbit of a planet by fitting a curve to a series of particular observed points along its route. Innumerable, very different curves are mathematically consistent with the observations, however, and the principle of enumerative induction offers no adequate basis for choosing among them.

Kepler unhesitatingly chose as the likeliest solution the simplest curve compatible with the observations. What justification is there for proceeding thus? C. S. Peirce in writing of this matter takes the view that of course Kepler was thinking in the scientifically correct manner, but that in order to make sense of such thinking we must presuppose that there is a supernatural power who designed the universe and who preferred simplicity to complexity in its laws. A good many other philosophers have said the same.

Yet, on the other hand, those wishing to evade theological assumptions may prefer to say merely that it is a basic feature of correct empirical reasoning that simpler hypotheses, if they are consistent with observations, are likelier to be true than are more complex hypotheses. In any case, complexity and simplicity need to figure prominently in our account of how science reaches its explanations. We must grant, of course, that the notions of complexity and simplicity, as they relate to scientific method, are not susceptible to strict formal definition; but neither are many other important notions that we understand and use, and we should be willing to accept some vagueness in our notions, despite the intense yearning for exact definitions that animates much traditional philosophy.

Dr. Peter Baofu has now taken up the notion of complexity, and will trace it through many of its modern variations. He will give it his own distinctive interpretation, and in his own way will seek to spell out the implications of this elusive yet essential notion.

Dr. Baofu is an unusual scholar. He has worked in many fields, lived in many countries, and written many books. In his extensive writings he has ranged over the natural sciences, the human sciences, politics and modern life, and prospects for the future. We must welcome this, his latest intellectual exploration, in which he confronts complexity.

Stephen F. Barker
Department of Philosophy
The Johns Hopkins University

This page intentionally left blank

Foreword

Once more, Dr. Peter Baofu throws down the gauntlet, challenging the reader to a new intellectual endeavor. Complexity—a twenty-first century predicament—is his subject this time. Not yet fully visible, and certainly not easily understood, but nevertheless intruding into everyone's daily life in its many disguises, complexity appears as the source of intellectual unrest, the obstructer of individual happiness, the confounder of organizational achievements, the source of national dilemmas, and the gargantuan ogre of international conflicts.

Indeed, we may well paraphrase Oliver Hazard Perry's statement one more time, as the 21st century begins, “We have seen the enemy and it is complexity”. Dr. Baofu cites the problem, presenting a summary of the sophisticated methods of computation in use at this time to address complexity in some of its many aspects. Thereafter, he presents highly creative pathways to illuminate the issue and critical tools to deconstruct the myths and euphoria surrounding it.

To those scholars who are grappling with complexity for the purpose of subduing it, this book describes complexity as a basic problem (with both promises and pitfalls), and serves as a launching pad for additional thinking and research, in light of his “dialectic theory of complexity”. It may well turn out that human thought together with the computer will produce pathways to harness complexity so it may quell international unrest, facilitate solutions to national dilemmas, serve the development of organizational achievements, and bring individuals out of personal consternations. But Dr. Baofu warns us against any false expectations.

Sylvan Von Burg
School of Business
George Washington University

Acknowledgments

Like all other books of mine, this one is written to challenge the dominant ideas and values, be they in the past or the present.

To maintain the spirit of intellectual impartiality, this book does not receive any external funding nor help from any formal organization or agency.

The only reward is the amazing feeling of discovering something new about the world and beyond—just as this is true for my previous books.

There is a person, however, that I should mention, and he is Sylvan von Burg at George Washington University School of Business, who writes the foreword for this book. His support of my intellectual endeavor is herein deeply appreciated.

In any event, I bear the sole responsibility for all the views expressed in this book.

This page intentionally left blank

Abbreviations

BWT = Peter Baofu. 2007. *Beyond the World of Titans, and the Remaking of World Order*. Cambridge, England: Cambridge Scholars Publishing, Inc.

BNN = Peter Baofu. 2006. *Beyond Nature and Nurture: Conceivng a Better Way to Understand Genes and Memes*. Cambridge, England: Cambridge Scholars Publishing, Inc.

FPHST = Peter Baofu. 2006. *The Future of Post-Human Space-Time: Conceivng a Better Way to Understand Space and Time*. New York: Peter Lang Publishing, Inc.

BCIV = Peter Baofu. 2006. *Beyond Civilization to Post-Civilization: Conceiving a Better Model of Life Settlement to Supersede Civilization*. NY: Peter Lang Publishing, Inc.

BCPC = Peter Baofu. 2005. *Beyond Democracy to Post-Democracy: Conceiving a Better Model of Governance to Supersede Democracy*. NY: The Edwin Mellen Press.

BDPD = Peter Baofu. 2004. 2 volumes. *Beyond Democracy to Post-Democracy: Conceiving a Better Model of Governance to Supersede Democracy*. NY: The Edwin Mellen Press.

FPHC = Peter Baofu. 2004. *The Future of Post-Human Consciousness*. NY: The Edwin Mellen Press.

FCD = Peter Baofu. 2002. *The Future of Capitalism and Democracy*. MD: The University Press of America.

FHC = Peter Baofu. 2000. 2 volumes. *The Future of Human Civilization*. NY: The Edwin Mellen Press.

This page intentionally left blank

• PART ONE •

Introduction

This page intentionally left blank

• CHAPTER ONE •

Introduction: The Challenge of Complexity

> At the beginning of the 20th Century, there was a sense in many areas of science that the key discoveries had already been made. These impressions were later shaken by discoveries that opened up vast new areas of knowledge. In contrast, we are struck at the start of the 21st Century by the enormity of what we do not know. Prominent amongst these areas of ignorance is complexity. Advances made in the final two decades of the 20th Century only serve to underscore just how much we have yet to learn about complex phenomena.
>
> —David Green and David Newth (2001)

1.1. The Enticing Fad about Complexity

The popularity of studying complexity is fast becoming a new fad in the intellectual scene. Everywhere in any discipline, there is somehow a sub-field (or in some cases more than one) devoted to the use of computation and other means, in order to study complex phenomena.

Some good examples are not lacking, as they can include, to be cited here for illustration only—evolutionary computation, fractal analysis, artificial intelligence, genetic algorithms, computational sociology, algorithmic information theory, chaos theory (or ergodic theory), artificial life simulation, catastrophe theory, neural networks, computational complexity theory, cybernetics, Krohn-Rhodes complexity theory, computational aesthetics, computer simulation, specified complexity theory, cellular automaton, computational game theory, random walk hypothesis, machine learning, computability theory, chaotic inflationary theory, non-equilibrium thermodynamics, agent-based modeling, and irreducible complexity theory. (CSCS 2006; EOLSS 2006)

The list can go on, of course. But a natural question to ask is, What then are the promises and their pitfalls in this enticing fad about studying complex phenomena?

To answer this question, let us start from the beginning, by piecemeal: What exactly is meant by the term "complexity" in the title, in the first place? At the outset, the term "complexity" should be distinguished from related (but different) terms like "complicatedness", "randomness", and "arbitrariness", which have caused some confusion in the literature.

Firstly, to be "complex" does not have the same meaning as being "complicated". (WK 2006) The reason is that the opposite of complicatedness is "simplicity", whereas "independence" is the polar extreme of complexity.

In other words, "a complex structure uses interwoven components that introduce mutual dependencies and produce more than a sum of the parts"; on the other hand, "a complicated structure is one that is folded with hidden facets and stuffed into a smaller space". So, "complex is the opposite of independent, while complicated is the opposite of simple". (WK 2006)

However, complexity may sometimes imply complicatedness, but the two still do not have the same meaning.

Secondly, complexity does not necessarily entail "randomness", which refers to the property of a variable which has a determinable probability distribution over time. (WK 2006e) At times, in everyday usage, "randomness" may even refer to a kind of process with an uncertain outcome. In either way, "those studying complex systems would not consider randomness as complexity". (WK 2006)

And thirdly, nor does it mean that complexity is therefore "arbitrary", since a complex system can be "well-defined" in terms of units, interactions, state changes, and neighborhoods, for example—and thus not arbitrary. (WK 2006f)

That said—to say what complexity *is not* does not yet say what it *is*.

Many scholars in the literature specify a certain form of "emergence of a major overall effect from a slight initial change" as "a general characteristic of complexity models in general. In cybernetics it was the counterintuitive results; in catastrophe theory it was the discontinuity at a critical value of a control parameter, and in chaos theory it was the sensitive dependence on initial conditions, more popularly known as the butterfly effect, the idea of Edward Lorenz [1993] that a butterfly flapping its wings in Brazil could trigger a hurricane in Texas". (J. Rosser 2003)

In Chapter Two, a more systematic analysis of the main criteria for the classification of complex events will be provided.

For now, and with this clarification in mind—the challenging question to ask, if rephrased in a different way, therefore, is whether or not the study of complex phenomena can reveal recognizable patterns (with predictable outcomes) to enhance our understanding of reality, especially when it is embedded within the messy web of complexity. If so, what then are the limits?

This question seems more of a formidable challenge to the post-moderns in our time than to the pre-moderns in ancient time, since the simple life forms in antiquity did not require much of information processing on the enormously more complex scale which we nowadays confront, especially in this day and age of the Information Revolution.

The idea of complexity is therefore timely enticing nowadays, to the point that John Horgan (1995) warned us of the possibility of its being another intellectual fad, after a series of previous ones in the last few decades, as J. Barkley Rosser (2003) summarized this danger: “Horgan...criticizes the concept of 'complexity' more generally...as just the latest in a string of fads, 'the four C’s'. In his view these four C’s are cybernetics, catastrophe, chaos, and complexity. This reflects the approximate order of their appearance as broad, transdisciplinary fads, with cybernetics hot in the 1960s, catastrophe theory hot in the 1970s, chaos theory hot in the 1980s, and complexity coming in during the 1990s. In Horgan’s view each of these was overhyped, was a sort of intellectual bubble that blew up and then crashed. For him complexity is just the latest of these and will crash also”.

My job in this book, in the end, is to deconstruct some of the myths surrounding the nature of complexity and, in the process, to provide a better way to understand it in this world and beyond unto multiverses.

1.2. Intractability in Computational Complexity Theory

The caveat concerning the fad about complexity aside—the question is all the more urgent, since, in computational complexity theory, there is a well-established fundamental problem in information processing to solve complex problems: The more complex the problems are to be solved, the more intractable they are, because of space and time constraints.

In other words, “[c]omputational complexity theory is the study of the complexity of problems—that is, the difficulty of solving them. Problems can be classified by complexity class according to the time it takes for an algorithm to solve them as function of the problem size....Even though a problem may be solvable computationally in principle, but in actual practice it may not be that simple. These problems might require large amounts of time or an inordinate amount of space”. (WK 2006 & 2006a)

So, this means that “[t]here exist a certain class of problems that although they are solvable in principle they require so much time or space that it is not practical to attempt to solve them. These problems are called Intractable". (WK 2006)

With this problem of intractability in information processing in mind (as summarized in *Table 3.2*, together with another main constraint on computation, that is, the problem of Bremermann's fundamental limit)—what then is the answer to the question concerning the understanding and predictability of complex phenomena?

1.3. The Theoretical Debate

Scholars, however, disagree, over the ages, about the answer to this challenging question. There have been different approaches to study the issue.

Three main groups can be identified and summarized hereafter (and also in *Table 1.1*)—for the purpose of illustration.

Firstly, on one side of the theoretical debate is what I want to call, in the absence of a better term, the *deterministic* approach—in special (though not necessarily exclusive) relation to reductionism (as will be analyzed later, especially, though not only, in Chap. 5).

One version of determinism is moderate enough, in arguing that all complex phenomena, even if they are not well understood now, will one day be so (at least in principle), to the extent that they inherently follow some recognizable patterns along the line of some fundamental laws or principles to be discovered. Albert Einstein, for instance, once famously said that "God does not play dice with the universe". (PW 2005)

A more radical version of determinism, however, is the one recently advocated by Stephen Wolfram, who argued, in *A New Kind of Science*, that all complex phenomena in nature are governed, ultimately in a reductionistic way, by a few fundamental laws as revealed by way of computer simulation in the field of computation, with the rule 110 cellular automaton as an excellent example. (WK 2006)

Secondly, on the other side of the theoretical debate lies a second (different) approach which can be labeled, again in the absence of a better term, the *indeterministic* approach (as the opposite extreme of determinism), since there are scholars who, however, do not share the extreme and simplistic view of Wolfram nor the relatively more moderate one of Einstein.

The indeterminstic approach is all the more relevant in relation to emergentism (which will be further analyzed later, together with reductionism, especially though not exclusively, in Chap. 5). For now, it suffices to stress that there are different versions of indeterminism, just as there are different ones of determinism.

For instance, three main types of indeterminism are, if summarized in a few words, namely, (a) that "some events are uncaused" (e.g., in theistic theology), (b) that "there are non-deterministically caused events" (e.g., in quantum mechanics), and (c) that "there are agent-caused events" (e.g., in libertarianism). (WK 2006b; PP 2006)

So, should one pick either determinism or indeterminism, in a broad sense—or either reductionism or emergentism, in a small sense? If not, what then is the alternative?

Precisely here, my original contribution comes in, which constitutes my approach, that is, the third in the debate, to be known, in the absence of better words, as *the dialectic theory of complexity*.

1.4. The Dialectic Theory of Complexity

The third approach in the theoretical debate is mine, in that neither determinism nor indeterminism (or, for that matter, neither reductionism nor emergentism) is valid, since I originally propose hereafter, in the absence of better words, the *dialectic* approach—or more precisely, *the dialectic theory of complexity* (as summarized in *Table 6.1*).

There are five main theses here in my dialectic theory of complexity, namely, (a) the first thesis on the partiality-totality principle, (b) the second thesis on the order-chaos principle, (c) the third thesis on the regression-progression principle, (d) the fourth thesis on the predictability-unpredictability principle, and (e) the fifth thesis on the post-human response—to be analyzed in the rest of the book and summarized in the final chapter, Chap. 6.

1.5. Theory and Meta-Theory

Theory, however, does not exist in a vacuum, as it closely relates with concept, methodology, and ontology.

The relationship between concept and theory, on the one hand, is easy enough to grasp, since any theory requires a set of concepts in the process of explaining the relationships among different entities in the world as represented by the concepts.

What is more complicated, on the other hand, is the linkage between theory and meta-theory (that is, methodology and ontology). A theory also depends, even if so often implicitly understood, on a certain approach to methodology and a certain kind of ontology as its (often hidden) meta-theoretical assumptions.

My dialectic theory of complexity is no exception, since it also depends on my distinctive approach to methodology (viz., "sophisticated methodological holism") and my unique kind of ontology (viz., "existential dialectics")—as will be hereafter introduced in the next two sections).

But where does this meta-theory come from? My methodology and ontology do not fall from the sky, for sure, since they constitute the accumulated wisdom (based from my previous works over the years while working on different theories in numerous fields), which has led me to wonder that there is a better way to do methodology and ontology so as to help us understand reality in all domains of knowledge, be they in the natural sciences, the humanities, and the social sciences.

The methodology and ontology hereafter introduced are not written in stone, as they constantly interact with the theories that I have developed over the years. It is not a one-way street from meta-theory to theory or vice-versa (that is, from theory to meta-theory), but a two-way street, in that the two (theory and meta-theory) constantly interacts with each other, so that I often have new ideas to update in regard to theory and meta-theory in any new book of mine on any subject, and this book is no exception.

1.6. The Ontology of Existential Dialectics

With this note on theory and meta-theory in mind—it is now easier to understand that this book is therefore built on the theoretical foundation of my previous books (especially in relation to what I worked out previously as "the logic of existential dialectics"), as each book serves as a building stone for the next one—just as each floor in a high-rise building serves as a foundation for the next higher one, by analogy. In other words, this book is written in conversation with them.

Examples of my previous books include the 2-volume work titled *The Future of Human Civilization* (hereafter abbreviated as *FHC*), *The Future of Capitalism and Democracy* (hereafter abbreviated as *FCD*), *The Future of Post-Human Consciousness* (hereafter abbreviated as *FPHC*), the 2-volume work titled *Beyond Democracy to Post-Democracy* (hereafter abbreviated as *BDPD*), *Beyond Capitalism to Post-Capitalism* (hereafter abbreviated as *BCPC*), *Beyond Civilization to Post-Civilization* (hereafter abbreviated as *BCIV*), *The Future of Post-Human Space-Time* (hereafter abbreviated as *FPHST*), *Beyond Nature and Nurture* (hereafter abbreviated *BNN*), and *Beyond the World of Titans, and the Remaking of World Order* (hereafter abbreviated as *BWT*).

In this sense, a summary of my previous works (in the context of the logic of existential dialectics) is deemed useful in this section, although it is my expectation that the reader is to read these previous works of mine for more details.

This summary (at times verbatim) is something that I often do in each new book, both as a reminder to those who know my previous books and as an introduction to those who never read them.

The summary can be divided into four sub-sections, namely, (1.6.1) the conception of existential dialectics, (1.6.2) the pragmatics of existential dialectics, (1.6.3) the syntax of existential dialectics, and (1.6.4) the semantics of existential dialectics—to be introduced hereafter, respectively.

1.6.1. The Conception of Existential Dialectics

A good starting point concerns my *conception* of existential dialectics, which can shed some light on my dialectical theory of complexity here, since both share a dialectic viewpoint.

The first theoretical foundation of my original work on the conception of existential dialectics as an ontological logic starts with *FHC*, *FCD*, and *FPHC*.

These earliest books were followed by *BDPD* and *BCPC*, which provided a further elaboration of my model of dialectic logic. In fact, in *BCPC*, I explicitly spelt out the three principles as the syntax of existential dialectics (to be summarized shortly).

At the outset, it is important to remember that the word 'existential' in "existential dialectics" has nothing to do with Existentialism, which I rebuked in *FHC*, *FCD*, and also *FPHC*. Rather, it simply refers to the existence of intelligent life (both primitive and advanced), in a broad sense.

The conception of existential dialectics relies on different concepts (like "sets", "elements", "relations,", "operations", "functions", "truth values", "axioms", "postulates", and "principles"—as shown in *Table 6.4*), for the understanding of the ontological logic.

1.6.2. The Pragmatics of Existential Dialectics

This conception of existential dialectics is not an idle academic exercise, since it can be put for good use in practice, that is, in relation to its *pragmatics*.

The pragmatics of existential dialectics constitutes an attempt to understand reality at the ontological level, but in relation to its theoretical application at multiple levels—or just to cite an example, at the societal level as shown in the freedom/unfreedom and equality/inequality dialectics which were first worked out in *FHC* but later further refined in *FCD* and also *FPHC*.

This distinction between different levels of analysis (as will be elaborated later in the next section on what I called "methodological holism" in my previous books) is important, since existential dialectics is not reductionistic, in that all other levels of analysis are relevant too in understanding reality, and the ontological level is only one of them (as required by my methodological holism, to be summarized in the next section).

The pragmatics of existential dialectics can be summarized in terms of four parts, namely, (1.6.2.1) the theoretical application of existential dialectics, (1.6.2.2) the further application of existential dialectics, (1.6.2.3) direct and indirect applications of existential dialectics, and (1.6.2.4) the multiple levels of application—to be addressed in the following order.

1.6.2.1. *The Theoretical Application of Existential Dialectics*

With this caveat in mind—two examples of the theoretical application of existential dialectics can be summarized hereafter to reveal no freedom without unfreedom (as shown in *Table 1.2*) and no equality without inequality (as shown in *Table 1.3*), especially in relation to the seven dimensions of life existence originally analyzed in *FHC* (i.e., the technological, the everyday, the true, the holy, the sublime/beautiful, the good, and the just).

In Chap. 10 of *FCD*, I further showed the relationship between these two examples of the theoretical application of existential dialectics and my new vision to understand future forms of political and economic systems.

For instance, my vision of a path-breaking political system in future times is the different forms of "post-democracy" to supersede democracy unto the post-human age.

My vision of post-democracy was called "the theory of post-democracy" (as summarized in *Table 1.4*, *Table 1.5*, and *Table 1.6*), whereas *Table 1.7* explains the distinctions among democracy, non-democracy, and post-democracy. And *Table 1.8* lists the multiple causes of the emergence of post-democracy, while *Table 1.9* clarifies some possible misunderstandings in regard to post-capitalism and post-democracy.

The same can be said about my other vision to understand future forms of economic systems, that is, the different forms of "post-capitalism" to supersede capitalism unto the post-human age.

My vision of post-capitalism was referred to (in *FCD*, *BDPD* and *BCPC*) as "the theory of post-capitalism" (as summarized in *Table 1.10*, *Table 1.11*, *Table 1.12*, *Table 1.13*, and *Table 1.14*), while *Table 1.15*, *Table 1.16*, *Table 1.17*, and *Table 1.18* offer a comprehensive comparative analysis of capitalism with other forms hitherto existing in history.

And *Table 1.19* shows the distinctions among capitalism, non-capitalism, and post-capitalism, whereas *Table 1.20* lists multiple causes of the emergence of post-capitalism. In fact, here is another (the third, so far) theoretical relevance of existential dialectics, this time, in that there is no wealth without poverty (or the wealth/poverty dialectics).

Besides, these existential constraints apply to the age of pre-modernity, modernity, post-modernity, and, in the future, what I originally suggested in *FHC* as "after-postmodernity".

This is all the more so, in the "post-human" age at some distant point of "after-postmodernity", long after human extinction, to be eventually superseded by post-humans of various forms. Good candidates include, for instance, thinking robots, thinking machines, cyborgs, genetically altered superior beings, floating consciousness, and hyper-spatial consciousness. This post-human vision of mine was first originally worked out in *FHC* and further elaborated in both *FCD* and *FPHC*, for instance.

Therefore, a most fundamental question about intelligent life now has an answer, in that, if asked, "What is the future of human civilization?"—my answer in *FCD* (89) is thus: "As addressed in Chap. 7 of *FHC*, a later epoch of the age of after-postmodernity (that is, at some point further away from after-postmodernity) will begin, as what I called the 'post-human' history (with the term 'post-human' originally used in my doctoral dissertation at M.I.T., which was finished in November 1995, under the title *After Postmodernity*, still available at M.I.T. library, and was later revised and published as *FHC*). The post-human history will be such that humans are nothing in the end, other than what culture, society, and nature (with some luck) have shaped them into, to be eventually superseded by post-humans (e.g., cyborgs, thinking machines, genetically altered superior beings, and others), if humans are not destroyed long before then".

A shocking conclusion for many contemporaries is that "[t]he post-human history will therefore mark the end of human history as we know it and, for that matter, the end of human dominance and, practically speaking, the end of humans as well. The entire history of human civilization, from its beginning to the end, can be summarized by four words, linked by three arrows (as already discussed in *FHC*)":

Pre-Modernity → Modernity → Post-Modernity → After-Postmodernity

---

In *BDPD*, this thesis of mine was specifically labeled as "the theory of the evolution from pre-modernity to after-postmodernity", at the historical level.

With this background in mind, "[t]he end of humanity in the coming human extinction is the beginning of post-humanity. To say an untimely farewell to humanity is to foretell the future welcome of post-humanity". (P. Baofu 2002: 89) This thesis of mine was known in *BDPD* as "the theory of post-humanity", at the systemic level.

In Chap. 9 of *FCD* (367-8), I also proposed "that civilizational history will continue into the following cyclical progression of expansion, before it is to be superseded (solely as a high probability, since humans might be destroyed sooner either by themselves or in a gigantic natural calamity) by posthumans at some distant point in after-postmodernity (which I already discussed in *FHC*)" unto multiverses (different constellations of universes):

Local → Regional → Global → Solar → Galactic →
Clustery... → Multiversal

In *BDPD*, this thesis of mine was called "the theory of the cyclical progression of system integration and fragmentation", at the systemic level.

In *BWT*, a different version of this thesis is "the theory of cyclical progression of empire-building", at multiple levels (e.g., institutional, structural, systemic, and the like), in providing a better way to understand the logic of empire-building on earth and beyond.

In *BNN*, I further proposed "the theory of contrastive advantages" (which was originally worked out in *FCD*), to point out the interactions of multiple levels in action (e.g., the biological, the psychological, the structural, the systemic, the cultural, and so on) for humans and post-humans on earth and beyond.

But even greater transformations are to come in the post-human age. For instance, even the existence of human consciousness will be superseded one day too, with "floating consciousness" and "hyper-spatial consciousness" (as elaborated in *FPHC*) as a climax of evolution in consciousness, after the future extinction of human consciousness:

Primordial consciousness → Human consciousness →
Post-human consciousness (with floating consciousness and
hyper-spatial consciousness as a climax in the evolution
of consciousness)

In *BDPD*, these latest theses of mine were known as "the theory of floating consciousness" and "the theory of hyper-spatial consciousness", both at the cosmological and psychological levels (as summarized in *Table 1.21*, *Table 1.22*, and *Table 1.23*).

1.6.2.2. *The Further Application of Existential Dialectics*

Not less amazingly, in *BDPD* and later in *BCIV*, I further revealed the theoretical application of existential dialectics, this time, in arguing that there is no civilization without barbarity, with human civilization to be eventually superseded by what I originally analyzed as "post-human post-civilization" (which should not be confused with "post-human civilization"), in the context of the freedom/unfreedom and equality/inequality dialectics.

In the end, therefore, civilization cannot live without barbarity and has to learn to co-exist with it in ever new ways. So, it is no more imperative to preserve civilization than necessary to destroy barbarity, and the ideal of civilization is essentially bankrupt, to be eventually superseded by "post-civilization".

But this also requires some understanding of my analysis of the trinity of modernity and other ages. For instance, in both *FCD* and *FPHC*, I worked out the structure of "post-human civilization" in terms of the trinity of after-postmodernity (i.e., "free-spirited after-postmodernity", "post-capitalist after-postmodernity", and "hegemonic after-postmodernity").

Both conceptually and theoretically, it is important to remember that the trinity of after-postmodernity is a sequential extension of the trinity of modernity (i.e., "free-spirited modernity", "capitalist modernity", and "hegemonic modernity") and the trinity of postmodernity (i.e., "free-spirited postmodernity", "capitalist postmodernity", and "hegemonic postmodernity") as first proposed in *FHC*.

However, the trinity of pre-modernity (i.e., "pre-free-spirited pre-modernity", "pre-capitalist pre-modernity", and "hegemonic pre-modernity") was later elaborated in *BCIV* to complete the historical set from pre-modernity to after-postmodernity.

In *BDPD*, this thesis about the trinity of pre-modernity, modernity, postmodernity, and after-postmodernity was collectively known as "the theory of the trinity of modernity to its after-postmodern counterpart", at the cultural level (as summarized in *Table 1.24*, *Table 1.25*, *Table 1.26*, *Table 1.27*, and *Table 1.28*).

At the structural level, all these trinities are subject to the existential constraints (e.g., the freedom/unfreedom and equality/inequality dialectics in the context of "the cyclical progression of hegemony"), be the historical epoch in pre-modernity, modernity, postmodernity, or after-postmodernity in future times. In other words, each of the historical epochs has its ever new ways of coming to terms with the ever new (different) mixtures of freedom/unfreedom and equality/inequality.

This is importantly so, not because, as one is tempted to falsely assume, one certain way is superior (or better) than another in terms of achieving more freedom and less unfreedom, or more equality with less inequality.

On the contrary, indeed, in each of the historical epochs, each increase of unfreedom greets each freedom achieved, just as each increase of inequality welcomes each equality achieved, albeit in ever new (different) ways. In *BDPD*, this thesis of mine was labeled as "the theory of the cyclical progression of hegemony", at the structural level, though it was first analyzed in *FCD*.

In *BDPD*, some more theoretical applications of existential dialectics were further examined, in relation to five main features, in the context of the duality of oppression, namely, (a) that each freedom/equality achieved is also each unfreedom/inequality created, (b) that the subsequent oppressiveness is dualistic, both by the Same against the Others and itself and by the Others against the Same and themselves, (c) that both oppression and self-oppression can be achieved by way of downgrading differences (between the Same and the Others) and of accentuating them, (d) that the relationships are relatively asymmetric among them but relatively symmetric within them, even when the Same can be relatively asymmetric towards itself in self-oppression, and the Others can be likewise towards themselves, and (e) that symmetry and asymmetry change over time, with ever new players, new causes, and new forms, be the locality here on Earth or in deep space unto multiverses—as summarized in *Table. 1.29* and *Table 1.30*.

The same logic, by the way, also holds both in relation to wealth and poverty (as addressed in *BCPC* and summarized in *Table 1.31* on the wealth/poverty dialectics) and in relation to civilization and barbarity (as addressed in *BCIV* and summarized in *Table 1.32*, *Table 1.33*, *Table 1.34*, *Table 1.35*, and *Table 1.36* on the civilization/barbarity dialectics). In *BDPD*, this thesis on existential dialectics was called "the theory of existential dialectics", at the cosmological level.

1.6.2.3. *Direct and Indirect Applications of Existential Dialectics*

Another way to understand the pragmatics of existential dialectics is by way of the analysis of its direct and indirect applications (as summarized in *Table 6.6*).

In direct applications, the logic of existential dialectics can shed some theoretical insights on diverse phenomena in the world, and good instances are the exploitation of the principles of existential dialectics for the theoretical insights on the freedom/unfreedom dialectics, the equality/inequality dialectics, and the wealth/poverty dialectics (as introduced above).

My books like *FPHST* and *BNN* also use the principles to reveal some theoretical insights on the perspectives of space and time (as in *FPHST*) and of nature and nurture (as in *BNN*).

In indirect applications, however, the theoretical insights can further be used to reveal other phenomena directly from them (viz., the theoretical insights) and therefore indirectly from the principles themselves. A good instance is the use of the theoretical insights on the freedom/unfreedom and equality/inequality dialectics for the understanding of the civilization/barbarity dialectics.

This distinction between direct and indirect applications may be a little academic, since even in indirect applications, the phenomena under study can still be directly related back to the principles themselves. In the example as cited above, the civilization/barbarity dialectics can be directly related to the principles of existential dialectics without the intermediate role of the freedom/unfreedom and equality/inequality dialectics.

1.6.2.4. *The Multiple Levels of Application*

Besides, the theoretical insights can be applied to different levels of analysis—even though, in a given example, it may refer to one level only.

For instance, in the example concerning the freedom/unfreedom dialectics, it can be used at the structural level (e.g., in relation to the theory of the cyclical progression of hegemony), but it can be exploited as well for other levels (e.g., the theory of post-capitalism at the institutional level).

1.6.3. The Syntax of Existential Dialectics

All this application of existential dialectics at multiple theoretical levels of analysis reveals something interesting, in terms of different general principles—which constitute the *syntax* of existential dialectics.

In *BCPC*, I fine-tuned the logical structure of existential dialectics at the ontological level and proposed three major principles for the ontological logic, namely, (a) the regression-progression principle on the direction of history, (b) the symmetry-asymmetry principle on the relationships among existents, and (c) the change-constancy principle on the evolution of time, or in a more elegant term, the dynamics of space-time—as summarized in *Table 6.5* on the syntax of existential dialectics.

In *FPHST*, I further exploited these three principles to propose "the perspectival theory of space-time", for a better way to understand space and time—especially, though not exclusively, in relation to future post-human history (as summarized in *Table 1.37*, *Table 1.38*, and *Table 1.39*).

All these theses of mine afore-summarized (and with many others who have not been summarized here, because of space constraint and the relevancy of the topic in question) are presented in a holistic framework, to be shown instead in *Table 1.40* on civilizational holism and *Table 1.41* on my theories about civilizational holism. For more details, the reader should refer to my previous books as cited in the tables.

With all this in mind—this book here, that is, *The Future of Complexity* (or simply *FP*), is to add three more principles, on top of the three aforementioned, namely, (d) the partiality-totality principle on the relationships between the parts and the whole, (e) the order-chaos principle on the process of change, and (f) the predictability-unpredictability principle on the occurrence of things—as part of the ontological logic of existential dialectics.

The three principles will be illustrated in the rest of the book, albeit in the context of complexity.

With this theoretical background of my previous works on existential dialectics in mind, it is now easier to understand my dialectical theory of complexity in the way that it will analyzed in the rest of this book.

1.6.4. The Semantics of Existential Dialectics

Yet, these principles in existential dialectics by themselves are general, without telling us the specific meanings in a given context—which then requires the study of the *semantics* of existential dialectics.

As an illustration, in *FPHST*, I made use of the first three general principles (i.e., the change-constancy principle, the regression-progression principle, and the symmetry-asymmetry principle) to propose "the perspectival theory of space-time", for a better way to understand space and time—especially, though not exclusively, in relation to future post-human history (as summarized in *Table 1.37*). But, in the process I had to introduce concepts and theories specific to the field of physics and other related fields (e.g., "absolute space" and "absolute time" in "classical mechanics" and "relative space-time" in "the theory of relativity").

This semantic feature of existential dialectics is important, since it has a safeguard against the varieties of reductionism (both ontological and methodological) and, for that matter, of reverse-reductionism (as summarized in *Table 6.2*), especially when put in relation to the constraints as imposed by methodological holism.

As an illustration, in accordance to my methodological holism, while the dialectics makes sense at the ontological level and can be used to reveal theoretical insights on the other levels—however, it must be stressed that to understand a given level of phenomenon, one still must do a lot of homework to understand that level from the perspective of that level, not just those of others.

My methodological holism (as will be summarized in the section below and also in the Chap. 6 for the conclusion of the book) is to further clarify this safeguard against the varieties of reductionism and reverse-reductionism.

1.7. Sophisticated Methodological Holism

That said—in the analysis of complexity, even in the context of my dialectical theory of complexity, an understanding of my unique methodology to be used in this project is required, namely, what I already worked out in *FPHC* as "the theory of methodological holism" or "methodological holism" in short.

It should be clarified here that my approach of "methodological holism" does not oppose or exclude "methodological individualism" (as some reader may automatically presume, in accordance to conventional wisdom) but actually include it.

For this reason (and others too, as summarized in *Table 6.2* and *Table 6.3*), my version of methodological holism is *sophisticated*—not *vulgar* as sometimes used by inapt scholars using the same term.

With this clarification in mind—my methodological holism stipulates that an inquiry of any given phenomenon is more complete, if treated in the context of a comprehensive analysis at all relevant levels, which challengingly encompass all the domains of human knowledge, ranging from the natural sciences through the social sciences to the humanities—which is something that I had already done in all my previous books.

A good list of these levels in question are, namely, (a1) the micro-physical, (a2) the chemical, (a3) the biological, (a4) the psychological, (a5) the organizational, (a6) the institutional, (a7) the structural, (a8) the systemic, (a9) the cultural, (a10) the macro-physical (cosmological), and (a11) other relevant levels which are either a combination of all these levels or the practical applications with a combination of them.

Now, it should be stressed, as I did in all my previous books, that the classification here is solely generic, in that the levels can be reorganized in many different ways, insofar as none of the levels (if relevant to an inquiry in question) is ignored or dismissed, to avoid the danger of reductionism.

An excellent example is something that I did for some of my previous books (e.g., *FPHST*, *BCIV*, and *BNN*), in that a reorganization of the levels can be done by way of the four main perspectives of inquiry, namely, (b1) culture, (b2) society, (b3) the mind, and (b4) nature.

Here, culture in (b1) is culture in (a9). Society in (b2) refers to the organizational in (a5), the institutional in (a6), the structural in (a7), and the systemic in (a8). The mind (b3) stands for the chemical in (a2), the biological in (a3), and the psychological in (a4). And nature in (b4) is related to the micro-physical in (a1) and the macro-physical (cosmological) in (a10), for instance.

Of course, the four main perspectives in this new classification are not mutually exclusive; for instance, nature in (b4) overlaps a bit with the systemic in (a8), the chemical in (a2), and the biological in (a3).

Besides, there is also the important factor of luck (or randomness in the everyday non-technical meaning), but it is already implied or allowed in each of the four perspectives in question (that is, culture, society, the mind, and nature).

With this clarification in mind, one must also bear in mind that the comparison in the classification is not absolute, but relative, as there are often some shades of gray, not exactly black or white (analogously speaking).

Some further clarifications and qualifications of methodological holism are summarized in *Table 6.2* and *Table 6.3*.

1.8. Chapter Outline

The methodological holism aside—this book is then organized in accordance to four main perspectives as outlined above, namely, (a) complexity and nature, (b) complexity and the mind, (c) complexity and society, and (d) complexity and culture—of course together with an introduction at the beginning and a conclusion in the end.

In other words, the book is organized in four main parts, corresponding to the domains of nature, the mind, society, and culture (as reclassified in the previous section), with two more parts (i.e., the introduction and the conclusion).

Consequently, the book thus has six chapters, beginning with the introductory chapter here, that is, Chap. 1 titled *Introduction: The Challenge of Complexity*, where the enticing fad about complexity is introduced, together with the theoretical debate in the literature and my dialectic theory of complexity, in the context of my previous works on methodological holism and existential dialectics.

Chap. 2, titled *Natural Complexity*, looks into the nature of complexity from the perspectives of chemistry, micro-physics, and cosmology, with an evaluation of the strengths and weaknesses in each.

Chap. 3, titled *Mental Complexity*, then examines the nature of complexity from the perspectives of biology and psychology, with a critique of the models presented.

Chap. 4, titled *Societal Complexity*, addresses the nature of complexity from the perspective of society in general—or more specifically, from the various dimensions of society, that is, in relation to social organizations, social institutions, social structure, and social systems, together with a critical evaluation of each.

Chap. 5, titled *Cultural Complexity*, analyzes the last perspective of complexity, this time from the one of culture—or more specifically, from the multiple dimensions of religion, morality, epistemology, and aesthetics, also with a critique of the use (or at times, abuse) of each dimension.

The last chapter, titled *Conclusion: The Future of Complexity*, summarizes the whole project with the five theses in my dialectical theory of complexity, namely, (a) the first thesis on the partiality-totality principle, (b) the second thesis on the order-chaos principle, (c) the third thesis on the progression-regression principle, (d) the fourth thesis on the predictability/unpredictability principle, and (e) the fifth thesis on the post-human response.

In the end, the idea of complexity becomes a new fad in the community of scholars on complexity theory in our contemporary time. While it is still useful in being a big step for current humans to understand complexity, it is only a small step, by contrast, for distant posterity (and for that matter, post-humans) to understand the long odyssey of the future life world to come that we have never known….

1.9. Five Clarifications

This brief chapter outline aside—the last business of the day is to clarify five issues in relation to (a) my previous books, (b) the book sub-title, (c) the classification of levels, (d) the number of examples, and (e) the use of neologisms.

(a) Firstly, as already pointed out earlier, the dialectical theory of complexity is built on the theoretical foundation of my previous books (i.e., *FHC*, *FCD*, *FPHC*, *BDPD*, *BCPC*, *BCIV, FPHST*, *BNN*, and *BWT*).

While I am considerate enough to provide a summary of different theories of mine in *Section 1.6* and in different tables at the end of this chapter and other chapters, it is still my expectation that the reader is to read my previous books for more analysis. There is no substitute of doing hard homework for the acquisition of deep knowledge.

(b) Secondly, while the sub-title of this book contains the word "better", it should not be misinterpreted to misleadingly assume that the new theory is somehow "superior" or absolutely closer to the "truth" but only that it will fit in better, when considered in light of the different needs of culture, society, nature, and the mind in future history (especially though not exclusively in the post-human age), be it here on earth and beyond in multiverses.

By way of an analogy, for instance, capitalism can be regarded as better in relation to the different historical needs of culture, society, nature, and the mind in this post-Cold War age of ours, just as feudalism had the historical privilege to fit in better during the medieval era.

The term "better" in the sub-title is therefore a historically relative concept, and this is something I stressed time and again in my previous works like *FHC*, *FCD*, *FPHC*, *BDPD*, *BCPC*, *BCIV*, *FPHST*, *BNN*, and *BWT*.

(c) Thirdly, my methodological holism is highly flexible in terms of classifying the different levels of analysis (or re-organizing them in different ways). The classification is not "written in stone", so as speak; it can be re-organized in ever new ways, insofar as no relevant levels of analysis are ignored in any scholarly project.

Besides, even the different theories of mine can be re-classified in relation to different levels of analysis, insofar as it can enhance our understanding of reality in a new way.

For instance, the theory of floating consciousness is classified at the psychological level, but it can equally be valid to have it classified instead at the cosmological level. By the same logic, the theory of cyclical progression of hegemony is classified at the structural level, but it can also be re-classified at the institutional level, for instance.

(d) Fourthly, the case studies and examples used throughout the book are by no means exhaustive but solely illustrative. After all, I have always stressed, both hereafter and in all of my previous books, that the case studies and examples are not necessarily mutually exclusive, as they can be reclassified in a different way; besides, exceptions are allowed.

Of course, since they are not exhaustive, one can always ask for more case studies and examples, but adding more of them does not necessarily change much of the conclusions to be drawn and may even lead to redundancy.

The case studies and examples used in this book are chosen with care and deemed sufficient for the purpose at hand, even though they are solely illustrative.

(e) And fifthly, I use different neologisms in my works, mostly to introduce my original concepts and theories, and good instances include those here or elsewhere in my previous books (e.g., "the dialectic theory of complexity", "the perspectical theory of space-time", "post-civilization", "hyper-spatial consciousness", "post-capitalism" and whatnot). Surely, they are used here solely for our current intellectual convenience, as they will be renamed differently in different ways in future history.

In *FCD* (508-9), I strongly reminded the reader that "all these terms 'post-capitalism', 'post-democracy'...and other ones as introduced in...[the] project (e.g.,...'posthuman elitists', and 'post-human counter-elitists', just to cite a few of them) are more for our current intellectual convenience than to the liking of future humans and post-humans, who will surely invent more tasteful neologisms to call their own eras, entities, and everything else, for that matter. But the didactic point here is to use the terms to foretell what the future might be like, not that its eras and entities must be called so exactly and permanently. After all, William Shakespeare (1995: Act II, Scene II, Line 47) well said long ago: 'What is in a name? That which we call a rose by any other name would smell as sweet'".

As I had said many times before, each of the neologisms can be re-written as a different "X", only to be re-named differently by the powers that be in different eras of future history.

With these clarifications in mind—I now turn to Chap. 2 on complexity and nature.

Table 1.1. The Theoretical Debate on Complexity (Part I)

- **Determinism (and Reductionism)**
  - One version of determinism is moderate enough, in arguing that all complex phenomena, even if they are not well understood now, will one day be so (at least in principle), to the extent that they inherently follow some recognizable patterns along the line of some fundamental laws or principles to be discovered. Albert Einstein, for instance, once famously said that "God does not play dice with the universe". (PW 2005)
  - A more radical version of determinism is the version recently advocated by Stephen Wolfram, who argued that all complex phenomena in nature are governed, ultimately in a reductionistic way, by a few fundamental laws as revealed by way of computer simulation in the field of computation, with the rule 110 cellular automaton as an excellent example. (WK 2006)

- **Indeterminism (and Emergentism)**
  - There are different versions of indeterminism, just as there are different ones of determinism.
  - For instance, three main types of indeterminism can be, namely, (a) "some events are uncaused" (e.g., in theistic theology), (b) "there are non-deterministically caused events" (e.g., in quantum mechanics), and (c) "there are agent-caused events" (e.g., in libertarianism). (WK 2006b; PP 2006)

(continued on next page)

Table 1.1. The Theoretical Debate on Complexity (Part II)

- **The Dialectic Theory of Complexity**
  - There are five main theses here in my dialectic theory of complexity, namely, (a) the first thesis on the partiality- totality principle, (b) the second thesis on the order-chaos principle, (c) the third thesis on the regression-progression principle, (d) the fourth thesis on the predictability-unpredictability principle, and (e) the fifth thesis on the post-human response—to be analyzed in the rest of the book and summarized in the final chapter, Chap. 6.

Notes: The examples in each category are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they necessarily mutually exclusive. Some can be easily re-classified elsewhere. As generalities, they allow exceptions.

Source: A summary of *Sec. 1.4*—and for that matter, the rest of the book.

Table 1.2. No Freedom Without Unfreedom (Part I)

- **On Having**
  - *In Relation to the Technological*
    - (1) if freer from submission to Nature, then less free from ecological degradation (Deep and Social Ecology), even if in a hi-tech form
    - (2) if freer from technological inconvenience/backwardness, then less free from technological control and the loss of privacy
    - (3) if freer from technological (material) backwardness, then less free from the abusive (barbaric) maltreatment of the primitive Others
  - *In Relation to the Everyday*
    - (1) if freer from abject poverty, then less free from artificial needs/discontents (Frankfurt School)
    - (2) if freer from sensual suppression, then less free from violent sublimation (Freud)
    - (3) if freer from the snobbishness of high culture, then less free from the shabbiness (leveling-off effect) of mass culture (Tocqueville)
    - (4) if freer from the inefficiency of traditional "compassionate economy," then less free from the bondage of a "ruthless [competitive] economy" (Keynes)
    - (5) if freer from anarchy in the state of nature (system fragmentation), then less free from government regulations and controls in system integration

(continued on next page)

Table 1.2. No Freedom Without Unfreedom (Part II)

- **On Belonging**
  - *In Relation to the Good and the Just*
    (1) if freer from disciplinary society, then less free from society of control (Foucault)
    (2) if freer from the tyranny of one or a few, then less free from the tyranny of the majority (or sometimes, minority veto)
    (3) if freer from elitist decision making, then less free from political gridlock/cleavage
    (4) if freer from arbitrary (discretionary) administration, then less free from bureaucratic irrationality (Weber) and legal trickery (loopholes)

- **On Being**
  - *In Relation to the True*
    (1) if freer from unscientific dogmas, then less free from instrumental abyss (nihilism). Or conversely, if freer from meaninglessness, then less free from dogmas.
    (2) if freer from the bondage of partiality/partisanship (e.g., prejudice, discrimination), then less free from the danger of impartiality and neutrality (e.g., opportunism, unrealisticness, lack of compassion, inaction)
    (3) if freer from making generalizations, then less free from being unable to understand much of anything
  - *In Relation to the Holy*
    (1) if freer from collective conscience, then less free from social loneliness
    (2) if freer from religious absoluteness, then less free from spiritual emptiness
  - *In Relation to the Beautiful/Sublime*
    (1) if freer from artistic non-autonomy, then less free from aesthetic disillusion (deconstruction)

(continued on next page)

Table 1.2. No Freedom Without Unfreedom (Part III)

Notes: The examples in each category are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they necessarily mutually exclusive. And some can be easily re-classified elsewhere. As generalities, they allow exceptions.
Sources: From Chap. 10 of *FCD*, based on *FHC*

Table 1.3. No Equality Without Inequality (Part I)

- **On Having**
  - *In Relation to the Technological*
    - (1) if more equal in treating Nature with spiritual unity, then less equal in suppressing the dominant drive to transcend it altogether
  - *In Relation to the Everyday*
    - (1) if more equal in building social plurality, then less equal in leveling-off effects (e.g., the subsequent relative intolerance of high/intellectual ethos in mass culture industry)
    - (2) if more equal in socioeconomic distribution beyond a certain point, then less equal in efficiency (e.g., resentment, the erosion of work ethics)
    - (3) if more equal in urging an affirmative action program, then less equal in creating victim mentality (in oneself), stigma (from others), reverse discrimination (against the once privileged), and mediocracy (against the more able)

- **On Belonging**
  - *In Relation to the Good and the Just*
    - (1) if more equal in banning monarchic/oligarchic exclusion, then less equal in producing "the tyranny of the majority" or of "minority veto"
    - (2) if more equal in encouraging participatory decision making, then less equal in inducing political divisiveness (gridlock/cleavage in power blocs) and organizational oligarchy
    - (3) if more equal in institutionalizing a decentralized bureaucracy, then less equal in falling into more territorial/turf politics (intrigues)

(continued on next page)

Table 1.3. No Equality Without Inequality (Part II)

- **On Being**
  - *In Relation to the Beautiful /Sublime*
    (1) if more equal in accepting diverse styles ("anything goes" mentality), then less equal in artistic good quality (in leveling-off effects against the best)
  - *In Relation to the True*
    (1) if more equal in tolerating multiple viewpoints (no matter how extreme), then less equal in epistemic standards
  - *In Relation to the Holy*
    (1) if more equal in celebrating any cults and sects (no matter how questionable), then less equal in spiritual depth and authenticity

---

Notes: The examples in each category are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they mutually exclusive. And some can be easily reclassified elsewhere. As generalities, they allow exceptions.
Sources: From Chap. 10 of *FCD*, based on *FHC*

Table 1.4. The Theory of Post-Democracy I: The Priority of Freedom over Equality (Part I)

- **Differences**
  - *For the Aggressive Lions (the Strong Elitists)*
    (1) Setting up rank distinctions among unequals (e.g., between inferior humans and superior post-humans, or later among inferior post-humans and superior ones, relatively speaking)
    (2) Yearning for being not only distinguished from unequals, but also the first among equals (the best of the very best)
    (3) Soul-searching for a high spiritual culture (not the trashy one for the masses). Mass culture is a dirty joke for them.
  - *For the Manipulative Foxes (the Weak Counter-Elitists)*
    (1) Seeking a gentle hegemony by way of more communitarian concerns (for inferior humans and, later, inferior post-humans)
    (2) Being more sympathetic to less formal-legalistic institutions and values

- **Similarities**
  - *For both Lions and Foxes*
    (1) Exploring different spheres of non-human consciousness in the cosmos (something vastly superior than the human one)
    (2) Recognizing the democratic illusions (e.g., no freedom without unfreedom, no equality without inequality, or simply no justice without injustice, and vice versa)

(continued on next page)

Table 1.4. The Theory of Post-Democracy I: The Priority of Freedom over Equality (Part II)

Notes: The two callings and examples in each category are solely illustrative (not exhaustive), since there will be many different post-human value ideals in the distant future of post-human civilization. The comparison is also relative (not absolute) towards post-democracy, so this is not just a version of free-market democracy (nor Fascism/Nazism, as shown in the table on democracy, non-democracy, and post-democracy). Nor are they mutually exclusive. As generalities, they allow exceptions. And the specific forms of post-human post-democratic ideals need to be further developed in future after-postmodern history, as they will be different from the ones we now know. The point here is to solely give an extremely rough picture of a small part of the world to come that we have never known.
Source: From Chap. 10 of *FCD*. Refer to text for more info and references.

Table 1.5. The Theory of Post-Democracy II: The Priority of Equality over Freedom

- *Hybrid Versions of*
  - Ex: the Trans-Feminine Calling
  - Ex: the Trans-Sinitic Calling
  - Ex: the Trans-Islamic Calling
  - Ex: the Trans-Outerspace Calling

- *Qualifications*
  - These four versions of post-capitalist value ideals need not automatically be post-democratic, just as capitalism does not necessarily mean democracy. They are two different entities though closely related.
  - But up to a certain threshold of elevating equality at the farther expense of freedom, the democratic ideals will be overcome and cease to exist.
  - The overcome will not be socialist or communist, but post-democratic with no freedom without unfreedom and no equality without inequality, subject to the constraints of existential dialectics.

Notes: The callings are solely illustrative (not exhaustive), since there will be many different post-human value ideals in the distant future of post-human life-forms. The comparison is also relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions. And the specific forms of post-human post-democratic ideals need to be further developed in future after-postmodern history, as they will be different from the ones we now know. The point here is to solely give an extremely rough picture of a small part of the world to come that we have never known.
Source: From Chap. 10 of *FCD*. Refer to text for more info and references.

Table 1.6. The Theory of Post-Democracy III: The Transcendence of Freedom and Equality (Part I)

- **Transcending Freedom in Floating Existence**
  - *Freedom*: seeking an ultimate elimination of the body. Being without the body. The aim is to transcend freedom in the end into a metaphysical state (i.e., beyond the physique).
  - *Unfreedom*: yet facing difficult trade-offs. The sacrifice of bodily existence and its joyfulness. An eternal boredom in floating existence in dark deep space, though with alternative pleasures. There is no free lunch even in the state of transcending freedom.

- **Transcending Equality in the Rivalry of Cosmic Hegemony**
  - *Inequality*: competing to outlast other lifeforms in floating existence, or just marginalizing them for one's hegemonic expansiveness in the rest of the cosmos (and even beyond). Universalism is only for the mediocre.
  - *Equality*: accepting only those of one's rank as equal partners in the vast spacetime for cosmic supremacy. Even here, the aim is to transcend equality into a metaphysical state.

(continued on next page)

Table 1.6. The Theory of Post-Democracy III: The Transcendence of Freedom and Equality (Part II)

Notes: Do *not* confuse this transcendence of freedom and equality (as one version of post-democracy) with the naïve temptation to transcend the freedom/unfreedom and equality/inequality dialectics. Existential dialectics hold true for freedom and equality in all cultures and societies—past, present, or future (i.e., democracy, non-democracy, and post-democracy), regardless of whether freedom and equality are conventionally understood as "negative" or "positive."
Also, the two features and examples in each are solely illustrative (not exhaustive), since there will be many different post-human value ideals in the distant future of post-human lifeforms. The comparison is also relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions. And the specific forms of post-human ideals even for these radically alien floating lifeforms (and others unknown to us) need to be further developed in future after-postmodern history, as they will likely be different from the ones herein illustrated. The point here is to solely give a very rough picture of a small part of the extremely alien world to come that we have never known.
Source: From Chap. 10 of *FCD*. Refer to text for more info and references.

Table 1.7. Democracy, Non-Democracy and Post-Democracy (Part I)

- **Democracy**
  - *Theoretical Constructs*
    - The pursuit of freedom and equality (in various degrees), regardless of whether freedom and equality can be understood as "negative" or "positive"
      (1) more equality than freedom: The relative priority of the good over the right
      (2) more freedom than equality: The relative priority of the right over the good
  - *Types*
    - Only (1): Different versions of communitarian moral universalism
    - Only (2): Different versions of liberal moral universalism
    - (1) or (2): Different versions of anarchic (non-nation-state) moral universalism
    - (1) or (2): Different versions of postmodern moral localism

- **Non-Democracy**
  - *Theoretical Constructs*
    - The focus on (1') equality or (2') freedom, but not both, regardless of whether freedom and equality can be understood as "negative" or "positive"
  - *Types*
    - Only (1'): Different versions on the Far Left (e.g., Stalinism, Robespierrianism)
    - Only (2'): Different versions on the Far Right (e.g., Nazism, absolute monarchism)

(continued on next page)

Table 1.7. Democracy, Non-Democracy and Post-Democracy (Part II)

- **Post-Democracy**
  - *Theoretical Constructs*
    - The priority of (1”) equality over freedom, or (2”) freedom over equality, or (3”) the transcendence of freedom and equality, regardless of whether freedom and equality are “negative” or “positive”. In degree, (1”) or (2”) is less than (1’) or (2’) but more than (1) or (2)—respectively.
    - Like democracy and non-democracy, post-democracy is also subject to the freedom/unfreedom and equality/inequality dialectics (or existential dialectics in general).
    - Unlike democracy and non-democracy, post-democracy acknowledges the constraints of existential dialectics and no longer value freedom and equality as sacred virtues. There is no utopia, in the end; even were there one, dystopia would exist within it.
  - *Types*
    - (1”): Different versions of trans-Sinitic value ideals
    - (1”): Different versions of trans-feminine value ideals
    - (1”): Different versions of trans-Islamic value ideals
    - (1”): Different versions of trans-outerspace value ideals
    - (2”): Different versions of post-human elitist value ideals
    - (3”): Different versions of the value ideals of floating consciousness (etc.)

(continued on next page)

Table 1.7. Democracy, Non-Democracy, and Post-Democracy (Part III)

Notes: The examples are solely illustrative (not exhaustive), nor are they mutually exclusive. As generalities, they allow exceptions. "Negative" freedom is freedom "from" (e.g., freedom from poverty), whereas "positive" freedom is freedom "to" (e.g., freedom to the state of enlightenment). "Negative" equality is "procedural" equality (e.g., equality of opportunity), while "positive" equality is "substantive" equality (e.g., equality of outcome). Existential dialectics impose constraints on freedom and equality in democracy, non-democracy, and post-democracy, regardless of whether freedom and equality can be understood as "negative" or "positive" in conventional discourse. Therefore, do *not* confuse the transcendence of freedom and equality in (3'') with the naïve temptation to transcend existential dialectics. There is no utopia, in the end; even should there be one, it would not exist without dystopia embedded within it.
Sources: A summary, based on my previous works, especially Chap. 5 of *FHC*, Chaps. 5-10 of *FCD*, Chaps. 2-4 of *FPHC*, and Chaps. 1 & 7 of *BDPD*. The reader should consult the books for more analysis, as this is only a summary here.

Table 1.8. Multiple Causes of the Emergence of Post-Democracy (Part I)

- *At the Micro-Physical Level*
  - Ex: intelligent life without the human physical-chemical system
  - Sources: Chap. 7 of *FHC*; Chaps. 9-10 of *FCD*; Chap. 1 of *FPHC*

- *At the Chemical Level*
  - Ex: space radiation and toxins
  - Sources: Chap. 7 of *FHC*; Chaps. 9-10 of *FCD*

- *At the Bio-Psychological Level*
  - Ex: exo-biological evolution in deep space
  - Ex: genetic engineering of new beings
  - Ex: limits of cognitive partiality
  - Ex: illusions of emotional neutrality
  - Ex: human biological inequality
  - Sources: Chap. 2 & Chaps. 9-10 of *FCD*; Chap. 7 of *FHC*; Chap. 4 of *BCPC*; *BNN*

- *At the Institutional Level*
  - Ex: the flawed logic of equality
  - Ex: the conflicting nature of governance
  - Sources: Chap. 5 of *FHC*; Chaps. 6 & 10 of *FCD*; Chap. 3 of *FPHC*; Chaps. 2-5 of *BDPD*

- *At the Organizational Level*
  - Ex: e-civic alienation
  - Ex: the dark sides of formal-legalistic routines
  - Sources: Chap. 3 of *FHC*; Chap. 7 of *FCD*; Chap. 3 of *FPHC*

(continued on next page)

Table 1.8. Multiple Causes of the Emergence of Post-Democracy (Part II)

- *At the Structural Level*
  - Ex: ever new forms of inequities, at home and abroad
  - Ex: the emergence of China, women, and Islam as major actors
  - Sources: Chaps. 5-6 of *FHC*; Chaps. 7, 9 & 10 of *FCD*; Chaps. 4-5 of *BDPD*

- *At the Cultural Level*
  - Ex: freedom/unfreedom dialectics
  - Ex: equality/inequality dialectics
  - Sources: Chap. 5 of *FHC*; Chaps. 3, 9 & 10 of *FCD*; Chap. 4 of *FPHC*; Chap. 1 of *BDPD*; Chap. 4 of *BCPC*; *BCIV*

- *At the Systemic Level*
  - Ex: space habitats (in zero-gravity) and colonization
  - Ex: ultra advanced future info systems
  - Ex: qualitative demography
  - Ex: system fragmentation and integration
  - Sources: Chap. 7 of *FHC*; Chaps. 9 & 10 of *FCD*; *BWT*

- *At the Cosmological Level*
  - Ex: the colonization of multiverses
  - Ex: the expansion of floating consciousness
  - Ex: the spread of hyper-spatial consciousness
  - Sources: Chap. 7 of *FHC*; Chaps. 9 & 10 of *FCD*; Chap. 4 of *FPHC*; *FPHST*; *BWT*

Notes: The examples in each category are solely illustrative (not exhaustive), and some of the items can be reclassified somewhere else. Nor are they always mutually exclusive. Since they are generalities, exceptions are expected.
Sources: From *FHC*, *FCD*, *FPHC*, *BCPC*, *BDPD*, *BCIV*, *PPHST*, *BNN*, and *BWT*. See also *Table 1.40* and *Table 1.41* on my perspective on civilizational holism.

Table 1.9. Some Clarifications about Post-Capitalism and Post-Democracy (Part I)

- The prefix "*trans-*" in the first category of post-capitalism (with its four versions) refers to something "going beyond" (*not* "uniting" or "combining"). Ex: *Sec. 10.3.3* of *FCD*; *Sec. 2.4* & *Sec. 4.4* of *FPHC*; *Sec. 7.2* of *BCPC.*

- Such terms like "post-democracy", "post-capitalism", "post-human elitist", "trans-feminine calling", and the like as used in my works are more for our current intellectual convenience than to the liking of future humans and post-humans, who will surely invent more tasteful neologisms to call their own eras, entities, and everything else, for that matter. But the didactic point here is to use the terms to foretell what the future might be like, not that its eras and entities must be called so exactly and permanently. Ex: *Sec. 11.1* of *FCD*; *Sec. 7.2* of *BCPC.*

- The four versions in the first category of post-capitalist value ideals need *not* automatically be post-democratic, just as capitalism does *not* necessarily mean democracy. They are two different entities—though closely related. But up to a certain threshold of elevating equality at the farther expense of freedom, the democratic ideals will be overcome and cease to exist. The same is true for the post-human elitist calling in the second category of post-capitalism in relation to post-democracy, depending on the extent to which freedom is elevated at the expense of equality. Ex: *Sec. 10.4.3.3* of *FCD*; *Table 3.9* of *FPHC*; *Table 7.6* of *BDPD.*

- The comparison in each of the three realms of existence in all forms of post-capitalism is *not* absolute, but relative. Examples include "communal" vs. "individualistic", and the like. Ex: Notes in *Table 10.8*, *Table 10.9*, *Table 10.10*, & *Table 10.11* of *FCD*; Chaps. 2-4 of *FPHC*; *Sec. 7.2* of *BCPC.*

- The emergence of post-capitalism (and post-democracy, for that matter) has multiple causes (to *not* be reduced to one or only a few). Ex: Chap. 10 of *FCD*; Chaps. 2-4 of *FPHC*; *Sec. 1.3* & *Sec. 7.2* of *BCPC* (or *Table 1.8* & *Table 7.11*).

(continued on next page)

Table 1.9. Some Clarifications about Post-Capitalism and Post-Democracy (Part II)

- The specific forms of post-capitalism (and post-democracy, for that matter) need to be further developed in future after-postmodern history, as they will be different from the ones we now know. The point here is to solely give an extremely rough sketch of a world to come that we have never known. Ex: *Sec. 10.3.3* & *Sec. 10.4.3.3* of *FCD*; *Table 10.14* & *Table 10.15* of *FCD*; *Sec. 7.2* of *BCPC*.

- Post-capitalism is *not* better than capitalism in an "absolute" sense but only fits in better, on the basis of the historical contingency of culture, society, nature, and the mind in some future eras. The same is true for post-democracy in relation to democracy. The term "better" is historically relative in this sense. Ex: *Sec. 10.3.3* of *FCD*; *Sec. 1.7* of *BDPD*; *Sec. 1.5* of *BCPC*.

- All forms of post-capitalism and post-democracy are subject to the constraints of existential dialectics. In the process, the dialectic direction is to go beyond the conventional "either-or" dichotomies (e.g., freedom vs. unfreedom, equality vs. inequality, freedom vs. equality, individuality vs. communality, spirituality vs. materiality, formal legalism vs. informal legalism, etc.). As is true in post-civilization, to go beyond the dichotomies is to acknowledge the co-existence of both in each dichotomy, although the degree of scaling one over the over varies from case to case (e.g., the theory of post-capitalism I, the theory of post-capitalism II, the theory of post-democracy I, the theory of post-democracy II, etc.)—but is not to be extreme in largely favoring one over the other, on average (all things considered). There is no utopia to be had in the end; even should there be one, dystopia would exist within it. Ex: Chap. 5 of *FHC*; *Sec. 10.4.4.2* of *FCD*; *Sec. 1.5* of *BDPD*; *Sec. 1.3* of *BCPC*; *BCIV*.

(continued on next page)

Table 1.9. Some Clarifications about Post-Capitalism and Post-Democracy (Part III)

- All forms of post-capitalism are *not* part of a "teleological law", but of "historical trends" only. The same is also true for all forms of post-democracy. Ex: *Sec. 7.1* of *FHC*; *Sec. 9.5.3.2* & *Sec. 10.3.4.2* of *FCD*; *Sec. 7.2* of *BCPC*.

- All forms of post-capitalism, however different from each other though they are, share one common feature, in that they all inspire for a higher spiritual culture. The same is also true for post-democracy. Ex: *Sec. 10.3*, *Sec. 10.4* & *Sec. 10.5* of *FCD*; Chaps. 2-4 of *FPHC*; *Sec. 7.2* of *BCPC*.

- All forms of post-capitalism try to avoid the excess in capitalist consumerism by favoring more basic than artificial needs in *having*, but the quality and quantity of these "basic" needs will be measured by future standards, not by our current ones. Standards are historically relative. Ex: *Sec. 10.3*, *Sec. 10.4* & *Sec. 10.5* of *FCD*; Chap. 2 of *FPHC*; *Sec. 7.2* of *BCPC*.

- All forms of post-capitalism make use of a different degree of political authority with advanced info systems in future history and strives for higher spiritual cultures (especially in the post-human age), while acknowledging the constraints of existential dialectics and no longer valuing free market (as in capitalism) and economic control (as in non-capitalism) as sacred virtues. Ex: *Sec. 10.3.4.2*, *Sec. 10.3*, *Sec. 10.4* & *Sec. 10.5* of *FCD*; Chaps. 2-4 of *FPHC*; *Sec. 1.5* of *BDPD*; *Sec. 7.2* of *BCPC*.

Notes: The main points here are solely illustrative (not exhaustive) nor necessarily mutually exclusive, and the comparison is relative (not absolute). As generalities, they allow exceptions. The sections as cited are only illustrative (not exhaustive).

Sources: From *BCPC*. See also *FHC*, *FCD*, *FPHC*, and *BDPD*.

Table 1.10. The Theory of Post-Capitalism I.1:
By Group—
Ex: Spiritual/Communal in the Trans-Feminine Calling

- **More Communal Than Individual**
  - *Sharing*: learning from others, as different ideas mutually enrich
  - *Cooperative*: encouraging a sense of shared leadership and teamwork

- **More Informal-Legalistic Than Formal-Legalistic**
  - *Specific*: listening more from the heart than from the head, to know a person as a concrete, not as an abstract, unit
  - *Affective*: thinking and acting with others on a more affective tone. Business can mix with an emotional touch
  - *Ascriptive*: hiring (or firing) can be done on the basis of merit (or lack of it), but deep solidarity (sisterhood) is important too
  - *Particularistic*: making decisions on the basis of cost-benefit analysis, but a given group relationship is vital

- **More Spiritual Than Secular**
  - *Long-Term Looking*: sharing for a long-term relationship (e.g., love, friendship), not just for a short-term gain
  - *Loving/Caring*: showing compassion for the sufferings of others, without quickly blaming and pre-judging
  - *Respectful*: showing acceptance about others' feelings (and thoughts)

Notes: The categories and examples are solely illustrative, since there can be different versions, and the comparison is relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions. The specific forms of the trans-feminine version need to be further developed in future after-postmodern history, as they will be different from the ones we now know, since the prefix "trans-" here means going beyond or deconstructing the feminine values, while using them as the inspirational point at the beginning.
Source: From Chap. 10 of *FCD*. Refer to text for more info and references.

Table 1.11. The Theory of Post-Capitalism I.2: By Nation-State— Ex: Spiritual/Communal in the Trans-Sinitic Calling

- **More Communal Than Individualistic**
  - *Centralized*: being more top-down in management
  - *Collective*: encouraging more group cooperation
  - *Social*: investing in trust and connection

- **More Informal-Legalistic Than Formal-Legalistic**
  - *Specific*: knowing more of those related or connected
  - *Affective*: behaving in a paternalistic, hierarchical way
  - *Ascriptive*: favoring family members and those related
  - *Particularistic*: building connection (*guanxi*) as imperative

- **More Spiritual Than Secular**
  - *Expansionist*: diffusing civilizational values (e.g., the superiority complex of civilizationalism)
  - *Holistic*: synthesizing things into a panoramic horizon
  - *Historical*: learning from the lessons of the ancient past
  - *Respectful*: deferential to elders and superiors

Notes: The categories and examples are solely illustrative, since there can be different versions, and the comparison is relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions. The specific forms of the trans-Sinitic version need to be further developed in future after-postmodern history, as they will be different from the ones we know nowadays, since the prefix "trans-" here means going beyond or deconstructing the Sinitic values, while using them as the inspirational point at the beginning.
Source: From Chap. 10 of *FCD*. Refer to text for more info and references.

Table 1.12. The Theory of Post-Capitalism I.3: By Region— Ex: Spiritual/Communal in the Trans-Islamic Calling (Part I)

- **More Communal Than Individualistic**
  - *Collective:* building the webs of relationships to bind individuals
  - *Sharing*: cultivating the established "wisdom" through common experience
  - *Cooperative*: stressing harmony, solidarity, and commonality
- **More Informal-Legalistic Than Formal-Legalistic**
  - *Specific*: making efforts to know well the participants (family and larger community) in matters of common concern
  - *Affective*: mixing work with language and ritual on explicit religious (Islamic) ideals, texts, stories, and examples
  - *Ascriptive*: privileging local history and custom on relationships among kinship groups
  - *Particularistic*: preferring an unbiased insider with ongoing connections to all parties
- **More Spiritual Than Secular**
  - *Historical*: learning from the lessons of the past as a source of stability and guidance
  - *Deferential*: showing respect for age, experience, status, and leadership in communal affairs
  - *Honorable*: emphasizing face, dignity, prestige, and fairness
  - *Compassionate*: giving mercy and charity ("*Zahah*") to others

(continued on next page)

Table 1.12. The Theory of Post-Capitalism I.3: By Region— Ex: Spiritual/Communal in the Trans-Islamic Calling (Part II)

Notes: The categories and examples are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions. The specific forms of the trans-Islamic version need to be further developed in future after-postmodern history, as they will be different from the ones we now know, since the prefix "trans-" here means going beyond or deconstructing the Islamic values, while using them as the inspirational point at the beginning.

Sources: From Chap. 10 of *FCD*. Refer to text for more info and references, especially from the works by George Irani (2000) and C. Murphy (September 19, 2001).

Table 1.13. The Theory of Post-Capitalism I.4:
By Universe—
Ex: Spiritual/Communal in the Trans-Outerspace Calling
(Part I)

- **More Communal Than Individual**
  - *Cooperative*: requiring teamwork in small space habitats
  - *Sharing*: learning from, and enjoying being with, each other in a small group in outer space

- **More Informal-Legalistic Than Formal-Legalistic**
  - *Specific*: knowing more about each other to facilitate living and working together in space, both as fellow astronauts and space-mates
  - *Affective*: being friendly and social to each other as vital to working and living in small space quarters
  - *Ascriptive*: nurturing comaraderie among fellow astronauts as if they are family members over time
  - *Particularistic*: building work relationship with enduring memory in a space mission

- **More Spiritual Than Secular**
  - *Long-Term*: looking beyond selfish materialistic concerns in a precarious space environment with potential life or death
  - *Loving/Caring*: cultivating deep bondage for the success of a long term space mission
  - *Transcendent*: searching for life meaning in outer space

---

(continued on next page)

Table 1.13. The Theory of Post-Capitalism I.4:
By Universe—
Ex: Spiritual/Communal in the Trans-Outerspace Calling
(Part II)

Notes: The calling and examples in each category are solely illustrative (not exhaustive), since there will be many different outer-space value ideals in the distant future of space colonization. The comparison is also relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions. And the specific forms of trans-outer-space calling need to be further developed in future after-postmodern history, as they will be different from the ones we now know, since the prefix "trans-" here means going beyond or deconstructing the current outer-space values, while using them as the inspirational point at the beginning. The point here is to solely give an extremely rough picture of a small part of the world to come that we still do not know much about.
Source: From Chap. 10 of *FCD*. Refer to text for more info and references.

Table 1.14. The Theory of Post-Capitalism II: Spiritual/Individualistic in the Post-Human Elitist Calling (Part I)

- **More Individualistic Than Communal**
  - Setting up rank distinctions among unequals (e.g., between inferior humans and superior post-humans, or later among inferior post-humans and superior ones, relatively speaking)
  - Yearning for being not only distinguished from unequals, but also the first among equals (the best of the very best)
  - Recognizing the constraints of equality/inequality dialectics (or existential dialectics in general)

- **More Spiritual Than Secular**
  - Soul-searching for a high spiritual culture (not the trashy one for the masses). Mass culture is a dirty joke for them.
  - Exploring different spheres of non-human consciousness in the cosmos (something vastly superior than the human one)
  - Recognizing the constraints of freedom/unfreedom dialectics (or existential dialectics in general)

- **Qualifications**
  - Although post-human elitist post-democracy is comparable to post-human elitist post-capitalism in some respects, the former does not necessarily imply the latter (post-human elitist post-capitalism), just as democracy does not have to entail capitalism. They are two different (though related) entities.
  - But up to a certain threshold of incorporating government intervention with advanced info systems in future civilizations for higher spiritual concerns at the expense of the free market and materialist pursuit, the capitalist ideal will be overcome.
  - The overcome will not be Fascist or feudalistic, but post-capitalist, subject to the constraints of existential dialectics.

(continued on next page)

Table 1.14. The Theory of Post-Capitalism II: Spiritual/Individualistic in the Post-Human Elitist Calling (Part II)

Notes: The calling and examples in each category are solely illustrative (not exhaustive). The comparison is also relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions. And the specific forms of post-human elitist post-capitalism need to be further developed in future after-postmodern history, as they will be different from the ones we now know, while using them as the inspirational point at the beginning. The point here is to solely give an extremely rough picture of a small part of the world to come that we still do not know much about.
Sources: From Chap. 10 of *FCD* (and also *FPHC*, *BDPD*, and *BCPC*). Refer to the text for more info and references.

Table 1.15. Pre-Capitalist Value Ideals (Part I)

- **Hunting/Gathering Economics (roughly until 10,000-8,000 B.C.)**
  - *More Spiritual Than Secular*
    - Ex: subsistence level of existence, with little material comfort; highly superstitious
  - *More Communal Than Individualistic*
    - Ex: communal, with little or no social differentiation in tight nomadic groups
  - *More Informal-Legalistic Than Formal-Legalistic*
    - Ex: social relationships on tribal or familial basis, often with no more than 40 people (more or less) in a nomadic group

- **Feudalist Economics (around 12th-15th centuries)**
  - *More Secular Than Spiritual*
    - Ex: the preservation of the feudal monarchy in the web of power relationships among the king (the chief feudal lord), lords, vassals, and serfs
  - *Individualistic Than Communal*
    - Ex: serfs produce enough for themselves and then pay rent to their feudal superiors, with any surplus left for selling at the market in a nearby town.
  - *More Informal-Legalistic Than Formal-Legalistic*
    - Ex: the particularistic bondage between a lord and a vassal in terms of "homage" (promise to fight for the lord) and "fealty" (promise to remain faithful to the lord), in exchange of "fief" (land) for the vassal

(continued on next page)

Table 1.15. Pre-Capitalist Value Ideals (Part II)

- **Mercantilist Economics (around 17th-18th centuries)**
  - *More Secular Than Spiritual*
    - Ex: the promotion of trade and import of precious metals for the power and wealth of the state
  - *More Individualistic Than Communal*
    - Ex: the driving motive of self-interest in all participants
  - *More Informal-Legalistic Than Formal-Legalistic*
    - Ex: close working relationships among the state and domestic industries against foreign competition; collusion among technocrats, government officials, and merchants

- **Physiocratic Economics (around the 18th century)**
  - *More Secular Than Spiritual*
    - Ex: the promotion of agriculture as the main source of wealth
  - *More Individualistic Than Communal*
    - Ex: the special cultivation of the interest of the landowner class as inherently linked to that of society
  - *More Informal-Legalistic Than Formal-Legalistic*
    - Ex: collusion between the government and the landowner class to ensure other economic activities (e.g., manufacturing) to be contingent on a surplus of agricultural production

Notes: The categories and examples are solely illustrative, and the comparison is also relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions.

Sources: From *BCPC*, based on a reconstruction from data in F. Pearson (1999: Ch.2), WK (2004), ME (2002), IW (1995), NS (2004), G. Grenier (2002), WK (2004e), and WK (2004f)

Table 1.16. Capitalist Value Ideals (Part I)

- **More Individualistic Than Communal**
  - *Egoistic*: treating individuals, not as ends in themselves but as means to an end for the self
  - *Competitive*: fighting for market success to the point, in extreme cases, of seeking success for its own sake, instead of focusing on cooperation (collusion)
  - *Insatiable*: always wanting more for the self, accepting no limit of what to acquire

- **More Formal-Legalistic Than Informal-Legalistic**
  - *Diffusive*: knowing myriad others in business in a less specific way, without depth (other than for business)
  - *Emotion-Neutral*: thinking and acting with others on a less affective tone. Business does not mix with fraternization.
  - *Achievement-Oriented*: hiring (or firing) on the basis of merit (or lack of it), not ascription (family relationships)
  - *Unparticularistic*: making business deals on the basis of cost-benefit analysis. Business is not to be polluted with personal intimate relationships.

- **More Secular Than Spiritual**
  - *Pragmatic (Short-Term)*: thinking in terms not of historical veneration but of behavioral consequences in foreseeable time range
  - *Calculative*: guiding action in terms of cost-benefit analysis, instead of moral evaluation
  - *Transformative*: remaking everything at hand into something new, rather than adjusting it to existing norms and virtues

(continued on next page)

Table 1.16. Capitalist Value Ideals (Part II)

Notes: The categories and examples are solely illustrative since there can be different versions, and the comparison is also relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions. And it does not matter whether or not the value ideals are either "market"-capitalistic (more on relative freedom) or "state"-capitalistic (more on relative equality), since they both differ drastically from, say, socialism and, even more radically, communism.
Source: From Chap. 10 of *FCD*. Refer to text for more info and references.

Table 1.17. Different Versions of Capitalist Value Ideals (Part I)

- **Classical Economics (e.g., Adam Smith, David Ricardo)**
  - *More Secular Than Spiritual*
    - Ex: economic interest as the driving force of life, with "labor" as the main source of wealth
  - *More Individualistic Than Communal*
    - Ex: "perfect competition" among individuals, with the assurance of the "invisible hand" of the "free market"
  - *More Formal-Legalistic Than Informal-Legalistic*
    - Ex: business is business, based on formal "contractual relations".

- **Neo-Classical Economics (e.g., W. Stanley Jevons, Alfred Marshall)**
  - *More Secular Than Spiritual*
    - Ex: economic interest as the driving force of life, in special relation to the rationality of "utility" and "maximization" (e.g., "profit maximization" of the firm and "utility maximization" of the consumer)
  - *More Individualist Than Communal*
    - Ex: the focus on market "equilibria" as "solutions of individual maximization problems"; the use of "methodological individualism" to explain economic phenomena "by aggregating over the behavior of individuals"
  - *More Formal-Legalistic Than Informal-Legalistic*
    - Ex: business is business, based on formal "contractual relations".

(continued on next page)

Table 1.17. Different Versions of Capitalist Value Ideals (Part II)

- **Keynesian Economics (e.g., John Maynard Keynes)**
  - *More Secular Than Spiritual*
    - Ex: economic interest as the driving force of life, with special interest in the problem of "business cycles"
  - *More Individualistic Than Communal*
    - Ex: the role of the free market, but for the interventionist role of the government on occasions of "market failures" (e.g., the Great Depression)
  - *More Formal-Legalistic Than Informal-Legalistic*
    - Ex: business is business, based on formal "contractual relations".

- **Monetarist Economics (e.g., Milton Friedman)**
  - *More Secular Than Spiritual*
    - Ex: economic interest as the driving force of life, with special attention to issues about money supply and inflation
  - *More Individualistic Than Communal*
    - Ex: the role of the free market, with a minimal role of the government (especially the central bank) to solely maintain price stability
  - *More Formal-Legalistic Than Informal-Legalistic*
    - Ex: business is business, based on formal "contractual relations".

(continued on next page)

Table 1.17. Different Versions of Capitalist Value Ideals (Part III)

- **New Classical Economics (e.g., John Muth, Robert Lucas)**
  - *More Secular Than Spiritual*
    - Ex: economic interest as the driving force of life, with particular attention to issues concerning "rational expectations"
  - *More Individualist Than Communal*
    - Ex: the focus on how individuals engage in expectations of future economic events on the basis of all available info (not just on past data as in adaptive expectations)
  - *More Formal-Legalistic Than Informal-Legalistic*
    - Ex: business is business, based on formal "contractual relations".

- **Neo-Mercantilism (e.g., Japan and Germany after WWII)**
  - *More Secular Than Spiritual*
    - Ex: the pursuit of economic and political power of the state, away from the primacy of manufacturing (as in old mercantilism) towards the battle in advanced technology
  - *More Individualistic Than Communal*
    - Ex: the helping role of the state in economic development, with special favor to the interest of business and technocratic strata
  - *More Formal-Legalistic Than Informal-Legalistic*
    - Ex: business is still business, yet with some degree of close relationships between the state and the business/ technocratic strata (but not to the extreme extent as in old mercantilism).

Notes: The categories and examples are solely illustrative, and the comparison is also relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions.

Sources: From *BCPC*, and a reconstruction based on data from WK (2004a), WK (2004b), F. Pearson (1999: Chap. 2), WK (2004c), and WK (2004d)

Table 1.18. Contemporary Alternatives to Capitalist Value Ideals (Part I)

- **Marxian Economics (e.g., Karl Marx, Friedrick Engels)**
  - *More Spiritual Than Secular*
    - Ex: the concern with the freedom from labor alienation: "The realm of freedom actually only begins where labor which is determined by necessity and mundane considerations ceases" (K. Marx, *Capital*, v.3)
  - *More Communal Than Individualistic*
    - Ex: the utopian communes, where the state will "wither away"
  - *More Informal-Legalistic Than Formal-Legalistic*
    - Ex: the abolition of the oppressive "contractual relationships" in "capitalist production relations"

- **Eco-Feminist Economics (e.g., Francois d'Eaubonne)**
  - *More Spiritual Than Secular*
    - Ex: the abolition of male oppression of both women and nature, as two main dimensions of the same androcentric violence
  - *More Communal Than Individualistic*
    - Ex: the ecological crisis and the oppression of women as also threats to humanity as a whole
  - *More Informal-Legalistic Than Formal-Legalistic*
    - Ex: the compassion for the Others and the care of nature as vital to humane social relationships, not solely on the basis of formal "contractual relationships"

(continued on next page)

Table 1.18. Contemporary Alternatives to Capitalist Value Ideals (Part II)

- **Islamic Economics**
  - *More Spiritual Than Secular*
    - Ex: the rationality of *homo Islamicus* (with religious inspirations), not *homo economicus* in capitalist economics
  - *More Communal Than Individualistic*
    - Ex: the public virtue of payment of the *zakat* (for charity), as one of the five pillars of Islam, and the prohibition of usury (*riba*, meaning: interest)
  - *More Informal-Legalistic Than Formal-Legalistic*
    - Ex: social relationships based on Islamic norms (say, as indicated in the five pillars) — not on formal capitalist "contractual relationships"

Notes: The categories and examples are solely illustrative, and the comparison is also relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions.

Sources: From *BCPC*. A reconstruction based on data from F. Pearson (1999: Chap. 2), K. Marx (1999), and P. Baofu (2000; 2002; 2004)

Table 1.19. Capitalism, Non-Capitalism, and Post-Capitalism (Part I)

- **Capitalism**
  - *Theoretical Constructs*
    - Allocation of scarce resources among alternative wants largely by free market for competition (whose characteristics in its ideal form include, for instance, no barrier to entry or exit, homogeneity, perfect information, a large number of buyers/sellers, and perfect factor mobility)
    - More formal-legalistic than informal-legalistic, more individualistic than communal, and more material (secular) than spiritual
    - Either (1) minimal government or (2) relatively active government
  - *Types*:
    - Only (1): Different versions of market capitalism (e.g., USA)
    - Only (2): Different versions of welfare capitalism (e.g., Sweden)

(continued on next page)

Table 1.19. Capitalism, Non-Capitalism, and Post-Capitalism (Part II)

- **Non-Capitalism**
  - *Theoretical Constructs*
    - Allocation of scarce resources among alternative wants mainly by political authority for policies (which can be regulative, redistributive, symbolic, and participatory)
    - More informal-legalistic than formal-legalistic
    - Either (1') more individualistic (for the elites), often (though not always) for material (secular) concerns, or (2') more communal (for the masses), often (though not always) for spiritual concerns
  - *Types*
    - Only (1'): Different versions on the Right (e.g., Fascist corporate-state economy for the glory of the new Rome, medieval lord-vassal-serf economy for the power of the feudalistic order)
    - Only (2'): Different versions on the Left (e.g., Soviet command economy for the creation of the New Socialist Man)

(continued on next page)

Table 1.19. Capitalism, Non-Capitalism, and Post-Capitalism (Part III)

- **Post-Capitalism**
  - *Theoretical Constructs*
    - Allocation of scarce resources among alternative wants largely by political authority with advanced info systems in future civilizations, subject to existential dialectics. In degree of allocating by authority, post-capitalism is more than capitalism but less than non-capitalism.
    - More spiritual than secular (material)
    - Either (1”) more individualistic or (2”) more communal
    - Like capitalism and non-capitalism, post-capitalism is also subject to the freedom/unfreedom and equality/inequality dialectics (or existential dialectics in general). There is no utopia, in the end; even were there one, dystopia would exist within it.
    - Unlike capitalism and non-capitalism, post-capitalism makes use of a different degree of political authority with advanced info systems in future civilizations and strives for higher-spiritual cultures (especially in the post-human age), while acknowledging the constraints of existential dialectics and no longer valuing free market (as in capitalism) and economic control (as in non-capitalism) as sacred virtues.
  - *Types*:
    - Only (1”): Different versions of post-human elitist value ideals
    - Only (2”): Different versions of trans-Sinitic value ideals
    - Only (2”): Different versions of trans-feminine value ideals
    - Only (2”): Different versions of trans-Islamic value ideals
    - Only (2”): Different versions of trans-outerspace value ideals

(continued on next page)

Table 1.19. Capitalism, Non-Capitalism, and Post-Capitalism (Part IV)

Notes: The calling and examples in each category are solely illustrative (not exhaustive). The comparison is also relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions. And the specific forms of each calling need to be further developed in future after-postmodern history, as they will be different from the ones we now know, while using them as the inspirational point at the beginning. The point here is to solely give an extremely rough picture of a small part of the world to come that we still do not know much about.
Source: From Chap. 10 of *FCD*. Refer to the text for more info and references.

Table 1.20. Multiple Causes of the Emergence of Post-Capitalism (Part I)

- *At the Micro-Physical Level*
  - Ex: intelligent life without the human physical-chemical system
  - Ex: Mastering of quantum mechanics, electromagnetism, and other fields for the understanding of a broad range of anomalous experiences and the application for artificial intelligence for spiritual quest
  - Sources: Chap. 7 of *FHC*; Chaps. 9-10 of *FCD*; Chap. 1 of *FPHC*

- *At the Chemical Level*
  - Ex: space radiation and toxins
  - Sources: Chap. 7 of *FHC*; Chaps. 9-10 of *FCD*

- *At the Bio-Psychological Level*
  - Ex: exo-biological evolution in deep space
  - Ex: genetic engineering of new beings
  - Ex: limits of human cognition
  - Sources: Chap. 2 & Chaps. 9-10 of *FCD*; Chap. 7 of *FHC*; *BNN*

- *At the Institutional Level*
  - Ex: the flawed logic of the free market
  - Ex: the need of a post-autistic economics
  - Source: Chap. 10 of *FCD*

- *At the Organizational Level*
  - Ex: the dark sides of formal-legalistic routines
  - Sources: Chap. 3 of *FHC*; Chap. 7 of *FCD*; Chap. 3 of *FPHC*

(continued on next page)

Table 1.20. Multiple Causes of the Emergence of Post-Capitalism (Part II)

- *At the Structural Level*
  - Ex: ever new forms of inequities, at home and abroad
  - Ex: the emergence of China, women, and Islam as major actors
  - Sources: Chaps. 5-6 of *FHC*; Chaps. 7, 9 & 10 of *FCD*; Chaps. 4-5 of *BDPD*

- *At the Cultural Level*
  - Ex: freedom/unfreedom dialectics
  - Ex: equality/inequality dialectics
  - Sources: Chap. 5 of *FHC*; Chaps. 3 & 10 of *FCD*; Chap. 4 of *FPHC*; Chap. 1 of *BDPD*; *BCIV*

- *At the Systemic Level*
  - Ex: space habitats (in zero-gravity) and colonization
  - Ex: ultra advanced future info systems
  - Ex: qualitative demography
  - Ex: system fragmentation and integration
  - Sources: Chap. 7 of *FHC*; Chaps. 9 & 10 of *FCD*; *BWT*

- *At the Cosmological Level*
  - Ex: multiverses
  - Sources: Chap. 7 of *FHC*; Chaps. 9 & 10 of *FCD*; Chap. 4 of *FPHC*; *FPHST*; *BWT*

Notes: The examples in each category are solely illustrative (not exhaustive), and some of the items can be reclassified somewhere else. Nor are they always mutually exclusive. Since they are generalities, exceptions are expected.
Sources: From *FHC*, *FCD*, *FPHC*, *BCPC*, *BDPD*, *BCIV*, *BNN*, *FPHST*, and *BWT*. See also *Table 1.40* and *Table 1.41* on my perspective on civilizational holism.

Table 1.21. The Theory of Floating Consciousness (Part I)

- *At the Micro-Physical Level*
  - Ex: intelligent life without the human physical-chemical system

- *At the Chemical Level*
  - Ex: space radiation and toxins

- *At the Bio-Psychological Level*
  - Ex: exo-biological evolution in deep space
  - Ex: genetic engineering of new beings

- *At the Institutional Level*
  - Ex: post-capitalism
  - Ex: post-democracy

- *At the Organizational Level*
  - Ex: less legal-formalistic routines

- *At the Structural Level*
  - Ex: alien forms of violence

- *At the Cultural Level*
  - Ex: transcending freedom
  - Ex: transcending equality

- *At the Cosmological Level*
  - Ex: parallel universes
  - Ex: pocket universes

- *At the Systemic Level*
  - Ex: space habitats (in zero-gravity)

(continued on next page)

Table 1.21. The Theory of Floating Consciousness (Part II)

Notes: Each example draws from the works of different scholars in the field. For instance, at the cosmological level, the idea of parallel universes is from the theoretical speculation in quantum cosmology by Stephen Hawking and others, while the one of pocket universes comes from the theoretical work of Allan Guth at MIT. And at the institutional level, I proposed post-capitalism and post-democracy in *FCD*. In addition, the examples are solely illustrative (not exhaustive), and some of the items can be reclassified somewhere else. Nor are they always mutually exclusive. Since they are generalities, exceptions are expected.
Source: From Chap. 1 of *FPHC*

Table 1.22. Physical Challenges to Hyper-Spatial Consciousness

- **The Understanding of a Higher-Dimensional World of Space-Time**
  - Ex: 4 for traditional aspects of space-time (e.g., length, width, breadth and time) plus 6 more new dimensions in theory of hyper-space, with profound implications for practical applications to new forms of consciousness

- **The Mastering of Dark Matter and Dark Energy**
  - Ex: "ordinary matter" (e.g., atoms, molecules) as a mere 4.4% of the universe, with 23% made of "cold dark matter" and the rest (about 73%) of mysterious "dark energy", with fundamental significance to questions about the limit of the speed of energy (or info), the availability of energy for use, and the nature of space-time, just to cite some examples

- **The Exploration of Multiverses**
  - Ex: theoretical speculation of other universes (e.g., "baby universes", "gateways" in black holes, "wave function of the universe", "many worlds", "brane worlds"), with potentially seminary discoveries of different physical laws in relation to matter-energy and space-time, and vital differences to the future of post-human conquest of other universes (for the emergence of new forms of consciousness)

Notes: These examples are solely illustrative (not exhaustive), and some of the items can be reclassified somewhere else. Nor are they always mutually exclusive. Since they are generalities, exceptions are expected. The point here is to give a rough picture of the evolution of consciousness to the hyper-spatial consciousness and others totally unknown to current earthlings. As a note of clarification, it makes no difference to my argument as to whether or not the hyper-spatial consciousness may emerge before, during, and after floating consciousness.
Sources: From *Table 4.5* of *FPHC*. See *FHC*, *FCD* and *FPHC* for more info.

Table 1.23. Theoretical Speculations of Multiverses

- **"Baby Universes" (Ex: Andre Linde and others)**
  - Ex: In a flat universe theory, "even if our part of it eventually collapses,…some spots in the cosmos would suddenly start inflating on their own, creating brand-new 'baby universes'". (P. Baofu 2000: 623)

- **"Parallel Universes" (Ex: Stephen Hawking and others)**
  - Ex: In quantum cosmology, there allows the existence of infinite numbers of parallel universes, with tunneling among them. (M. Kaku 1994: 256) Hawking later revised his views on this.

- **"Pocket Universes" (Ex: Alan Guth)**
  - Ex: "As the pocket universes live out their lives and recollapse or dwindle away, new universes are generated to take their place.…While life in our pocket universe will presumably die out, life in the universe as a whole will thrive for eternity". (A. Guth 1997: 248; P. Baofu 2002: 482)

- **"Brane Worlds" (Ex: Warren Siegel, Lisa Randall, and others)**
  - Ex: Our universe is stuck on a membrane of space-time embedded in a larger cosmos, with different brane worlds connecting and/or colliding with each other.

Notes: These examples are solely illustrative (not exhaustive), and some of the items can be reclassified somewhere else. Nor are they always mutually exclusive. Since they are generalities, exceptions are expected.
Sources: From *Table 4.8* of *FPHC*. See *FHC*, *FCD* and *FPHC* for more info.

Table. 1.24. The Trinity of Pre-Modernity

- *Pre-Free-Spirited Pre-Modernity (Pre-Modernism) and Its Internal Split*
  - Competing worldviews and values both within and between linear-centric (e.g., Islamic, Christian, Judaic, Imperial Roman) and cyclical-centric (e.g., Confucian, Taoist, Hindu, and Buddhist) orientations
  - Compare modernism in *Table 1.5* (*BCIV*) with pre-modernism here in relation to the seven dimensions of human existence like the true and the holy (e.g., different versions of epistemic dogmas and religious superstitions), the everyday and the technological (e.g., different versions of non-technophilism and non-consumerism), the beautiful/ sublime (e.g., different versions of aesthetic non-autonomy), and the good and the just (e.g., different versions of moral particularism).

- *Pre-Capitalist Pre-Modernity (Pre-Modernization) and Its Own Discontents*
  - Competing versions of societal arrangements (e.g., feudalism, monarchism, and the holy order)

- *Hegemonic Pre-Modernity and Its Countervailing Forces*
  - Different power centers and their enemies (e.g., the Roman Empire and the "barbarian hordes", the "Holy Crusades" and the Muslims, the Middle Kingdom and the invading tribes, different social castes in India, and warring Greek city-states)

Notes: The examples in each category are solely illustrative (not exhaustive) nor necessarily mutually exclusive, and the comparison is relative (not absolute). As generalities, they allow exceptions. Also, it does not matter what the "base" era is in the analysis of any trinity. And in the present context, the "base" era is modernity (for instance, with its "free-spirited modernity" and the other two parts). So, for pre-modernity, the trinity takes the form of, say, "pre-free-spirited pre-modernity", together with the other two parts.
Sources: From Chap. 2 of *BCIV*. See also the 2 volumes of *FHC*.

Table 1.25. The Trinity of Modernity (Part I)

- **Free-Spirited Modernity (Modernism) and Its Internal Split**
  - *On the True and the Holy*
    - The freedom from the dogmas of the past to the better understanding of, and union with, the world and self (*FHC*: Chap. 3)
    - Alternative discourses: about the true (e.g., anti-science discourses) and the holy (non-mainstream theologies) (*FHC*: Chap. 3)
  - *On the Technological and the Everyday*
    - The freedom from life harshness to the higher technophilic, consumeristic lifeform (*FHC*: Chap. 2)
    - Alternative discourses: about the everyday (e.g., transcendental mindsets) and the technological (e.g., Arcadianism) (*FHC*: Chap. 2)
  - *On the Good and the Just*
    - The freedom from the theo-aristocratic tyranny to the moral universality for a just society (*FHC*: Ch.5)
    - Alternative discourses: about the just (e.g., Communism and Anarchism) and the good (e.g., Nazism/Fascism, and Zarathustrianism) (*FHC*: Chaps. 5-6)
  - *On the Beautiful and the Sublime*
    - The freedom from the external distortion of aesthetic pleasure to the boundless infinity of totality in artistic autonomy (*FHC*: Chap. 4)
    - Alternative discourses: about the beautiful/sublime (e.g., kitsch and historical avant-gardism) (*FHC*: Chap. 4)

(continued on next page)

Table 1.25. The Trinity of Modernity (Part II)

- **Capitalist Modernity (Modernization) and Its Own Discontents**
  - *During the Industrial Revolution*
    - Ex: Marx on the institution of inequality (*FHC*: Chap. 1)
  - *During the Modern Rational-Instrumental Epoch*
    - Ex: Weber on the politics of soft liberal institutions (*FHC*: Chap. 5)
  - *During the Great Depression*
    - Ex: Keynes on the myth of the free market (*FHC*: Chaps. 1,3)
  - *During the Cold War*
    - Ex: Lasch on the narcissistic culture industry (*FHC*: Chaps. 2-3)

- **Hegemonic Modernity and Its Countervailing Forces**
  - *The Legacies of Colonialism and Imperialism*
    - Ex: European colonization of most of the modern world (*FHC*: Chap. 1)
  - *The Struggle for Decolonialization*
    - Ex: The countervailing forces of resentment, rechantment, and regionalism (*FHC*: Chaps. 1 & 6)

Notes: The examples in each category are solely illustrative (not exhaustive) nor necessarily mutually exclusive, and the comparison is relative (not absolute). As generalities, they allow exceptions.
Sources: From the 2 volumes of *FHC*—and also from *FCD*

Table 1.26. The Trinity of Postmodernity (Part I)

- **Free-Spirited Postmodernity (Postmodernism) and Its Internal Split**
  - *On the True and the Holy*
    - Postmodern performative turn for knowing and its enemies (*FHC*: Chap. 3)
    - Postmodern comparative theology and its opponents (*FHC*: Chap. 3)
  - *On the Technological and the Everyday*
    - Postmodern corporate technological mindset and its adversaries (*FHC*: Chap. 2)
    - Postmodern postmaterialism and its critics (*FHC*: Chap. 2)
  - *On the Good and the Just*
    - Postmodern politics of difference and its foes (*FHC*: Chap. 5)
  - *On the Beautiful and the Sublime*
    - Postmodern deconstruction and its dissenters (*FHC*: Chap. 4)

- **Capitalist Postmodernity (Postmodernization) and Its Own Discontents**
  - *During the Post-Cold War and Beyond*
    - Ex: post-Fordism and its shortcomings (*FHC*: Chap. 6; *FCD*: Chaps. 6-7)

(continued on next page)

Table 1.26. The Trinity of Postmodernity (Part II)

- **Hegemonic Postmodernity and Its Countervailing Forces**
  - *The Debate on the Global Village*
    - Ex: uni-civilizationalism vs. multi-civilizationalism (*FHC*: Chap. 6)
  - *The Resistance Movement*
    - Ex: rechantment and the politics of civilizational claims (e.g., Islamic, Confucian and other ethos in relation to the Same) (*FHC*: Chap. 6; *FCD*: Chap. 10)
    - Ex: resentment and the politics of resurgence (e.g., the rising Chinese superpower, the growing EU, and other players in relation to the U.S. and her allies) (*FHC*: Chap. 6; *FCD*: Chap. 8)
    - Ex: regionalism and the politics of inequality (e.g., trans- or inter-national blocs, the North-South divide, NGO's) (*FHC*: Chap. 6; *FCD*: Chap. 5)

Notes: The examples in each category are solely illustrative (not exhaustive) nor necessarily mutually exclusive, and the comparison is relative (not absolute). As generalities, they allow exceptions.
Sources: From *FCD* and the 2 volumes of *FHC*

Table 1.27. The Trinity of After-Postmodernity

- *Free-Spirited After-Postmodernity (After-Postmodernism) and Its Internal Split*
  - The discourse of naked contingency (*FCD*: Chap. 10; *FPHC*: Chap. 4)

- *Post-Capitalist After-Postmodernity (After-Postmodernization) and Its Own Discontents*
  - Different versions of post-capitalism and post-democracy, and their enemies (*FCD*: Chap. 10; *FPHC*: Chaps. 3-4)

- *Hegemonic After-Postmodernity and Its Countervailing Forces*
  - The Cyclical Progression of Hegemony in Multiverses (*FCD*: Chaps. 9-10; *FPHC*: Chap. 4)

Notes: The examples in each category are solely illustrative (not exhaustive) nor necessarily mutually exclusive, and the comparison is relative (not absolute). As generalities, they allow exceptions.
Sources: From *FCD* and also *FPHC*

Table 1.28. The Civilizational Project from Pre-Modernity to After-Postmodernity (Part I)

	Pre-Modern	*Modern*	*Post-modern*	*After-Post-modern*
Main narratives	•Sacralness •Courtliness •Vitalism •Animism	•Freedom •Equality •Fraternity	•Multiplicity •Hybridization	•Naked contingency •Cyclical progression of hegemony
Main institutions	•Monarchy •Aristocracy •Feudalism •Holy order •Primitivism	•Capitalism •Liberalism •Socialism •Nazism •Fascism	•Capitalism •Liberalism •Postmodern politics of difference	•Post-Capitalism •Post-Democracy •Others
Main technological & economic revolutions	•Agricultural	•Service •Industrial	•Informational	•Biological •Material •Energy •Space •Others
Main agents	•Males •Upper strata •Mini-states	•Males •Upper strata •Whites •Empires	•Males •Upper strata •Whites •Others •Supra-states •IO's	•Post-humans •Humans •Others

(continued on next page)

Table 1.28. The Civilizational Project from Pre-Modernity to After-Postmodernity (Part II)

	Pre-Modern	*Modern*	*Post-modern*	*After-Postmodern*
Main impacts	•Local	•Inter-national	•Global	•Outer-space •Multiverse
Main outcomes	•Towards moderntiy •Rise of linear- & cyclical-centric civiliza-tions	•Towards post-moderni-ty •Domi-nance of linear-centric civiliza-tion	•Towards after-post-moderntiy •Linear-centric civiliza-tion in crisis	•Towards human (& maybe post-human) extinction •Rise of post-civiliza-tion, especially though not only, in post-human forms of space-time

Notes: The examples in each category are solely illustrative (not exhaustive) nor necessarily mutually exclusive, and the comparison is relative (not absolute). As generalities, they allow exceptions.
Sources: From *Table 10.16* of *FCD* and also from *BCIV* and *FPHST*

Table 1.29. The Duality of Oppression in Existential Dialectics: Oppression and Self-Oppression (Part I)

- **From the Same to the Others and Itself**
  - *The Oppression by the Same against the Others*
    - By way of downgrading differences
      - Ex: on judiciary caprice for corporate crimes (*Sec. 2.2.1.2.1*)
      - Ex: on the deceptive politics of liberation (*Sec. 3.5*)
      - Ex: on the humanitarian mystique (*Sec. 4.4*)
      - Ex: on the fad of emotional intelligence (*Sec. 5.3*)
    - By way of accentuating differences
      - Ex: on the legal sophistry of self-defense (*Sec. 2.3*)
      - Ex: on the legal semantics of proportionality (*Sec. 2.4*)
      - Ex: on the tricky politics of external threat (*Sec. 3.4*)
      - Ex: on the appeal of the Far Right for democracy (*Sec. 5.4*)
      - Ex: on the democratic axis of evil (*Sec. 5.5*)
      - Ex: on the democratic way of brutality and revenge (*Sec. 5.6*)
      - Ex: on democratic autocracy (*Sec. 6.4*)
  - *The Oppression by the Same against Itself*
    - By way of downgrading differences
      - Ex: on the politics of fear (*Sec. 2.2*)
      - Ex: on the trickery of compassionate conservatism (*Sec. 3.2*)
      - Ex: on the deceptive politics of patriotism (*Sec. 3.3*)
    - By way of accentuating differences
      - Ex: on the caprice of due process on domestic suspects (*Sec. 2.2*)
      - Ex: on the false security/freedom dilemma (*Sec. 6.5.2*)

(continued on next page)

Table 1.29. The Duality of Oppression in Existential Dialectics: Oppression and Self-Oppression (Part II)

- **From the Others to the Same and Themselves**
  - *The Oppression by the Others against the Same*
    - By way of downgrading differences
      - Ex: on judiciary caprice in the reverse direction (*Sec. 2.2.1.2.2*)
      - Ex: on equal pay (*Sec. 6.2.1.1*)
      - Ex: on equal representation (*Sec. 6.2.1.2*)
      - Ex: on affirmative action program (*Sec. 6.3.1.1*)
      - Ex: on same-sex marriage (*Sec. 6.3.1.2*)
    - By way of accentuating differences
      - Ex: on sexual harassment (*Sec. 6.2.2.1*)
      - Ex: on physical violence (*Sec. 6.2.2.2*)
      - Ex: on sexual exploitation (*Sec. 6.2.2.3*)
  - *The Oppression by the Others against Themselves*
    - By way of downgrading differences
      - Ex: on the reverse-class mystique (*Sec. 4.2*)
      - Ex: on the reverse-black mystique (*Sec. 4.3*)
      - Ex: on self-discrimination by downgrading (*Sec. 6.3.2.2*)
    - By way of accentuating differences
      - Ex: on self-discrimination by accentuating (*Sec. 6.3.2.1*)

Notes: The examples are solely illustrative (not exhaustive), nor are they mutually exclusive. As generalities, they allow exceptions. Also, both forms of oppression co-exist in all of the examples, so the listing of them are only meant in a relative, not absolute, sense.
Source: A summary of the sections (as cited) in Chaps. 2-6 of *BDPD*. See text for more info and references.

Table 1.30. The Structure of Existential Dialectics I: The Freedom/Unfreedom and Equality/Inequality Dialectics

- Each freedom and equality produces its own unfreedom and inequality, regardless of whether the pair occurs in political society (with the nation-state), in civil society (with some autonomy from the state), or elsewhere (e.g., in the private sphere of individual homes) — and regardless of whether freedom and equality are understood as "negative" or "positive".

- Oppression is dualistic, as much by the Same against the Others and itself, as by the Others against the Same and themselves.

- Both forms of oppression and self-oppression can be achieved by way of downgrading differences (between the Same and the Others) and of accentuating them.

- The relationships are relatively asymmetric between the Same and the Others and relatively symmetric within them. This is true, even when the Same can be relatively asymmetric towards itself in self-oppression, just as the Others can be likewise towards themselves.

- Symmetry and asymmetry change over time, with ever new players, new causes, and new forms.

Notes: The examples in each category are solely illustrative (not exhaustive) nor necessarily mutually exclusive, and the comparison is relative (not absolute). As generalities, they allow exceptions. "Negative" freedom is freedom "from" (e.g., freedom from poverty), whereas "positive" freedom is freedom "to" (e.g., freedom to the state of enlightenment). "Negative" equality is "procedural" equality (e.g., equality of opportunity), while "positive" equality is "substantive" equality (e.g., equality of outcome). Existential dialectics impose constraints on freedom and equality in democracy, non-democracy, and post-democracy. There is no utopia, in the end; even should there be one, dystopia would exist within it.
Sources: From *Table 1.5* of *BDPD*—and also from *FHC*, *FCD*, and *FPHC*

Table 1.31. The Structure of Existential Dialectics II: The Wealth/Poverty Dialectics

- There is no wealth without poverty, just as there is no poverty without wealth.

- The wealth/poverty dialectics occurs in the realms of having, belonging, and being, in relation to the material, relational, and spiritual.

- The wealth/poverty dialectics also expresses itself at the multiple levels of analysis in accordance to methodological holism, be they about the micro-physical, the chemical, the biological, the psychological, the organizational, the institutional, the structural, the systemic, the cultural, and the cosmological.

- The wealth/poverty dialectics is a different manifestation of existential dialectics in general, subject to the principles in its logic of ontology — just as the freedom/unfreedom and equality/inequality dialectics are likewise.

- There is no economic utopia, in the end; even should there be one, dystopia would exist within it.

Notes: The main points here are solely illustrative (not exhaustive) nor necessarily mutually exclusive, and the comparison is relative (not absolute). As generalities, they allow exceptions.
Sources: From *BCPC*. See also *FCD* and *FHC*.

Table 1.32. The Structure of Existential Dialectics III: The Civilization/Barbarity Dialectics

- There is no civilization without barbarity.

- The civilization/barbarity dialectics applies in the four civilizing processes (e.g., the rationalizing process, the pacifying process, the stewardizing process, and the subliming process).

- The civilization/barbarity dialectics is another (different) manifestation of existential dialectics in general, subject to the principles in its logic of ontology — just as the freedom/unfreedom and equality/inequality dialectics and the wealth/poverty dialectics are likewise.

- There is no utopia, in the end; even should there be one, dystopia would exist within it.

Notes: The main points here are solely illustrative (not exhaustive) nor necessarily mutually exclusive, and the comparison is relative (not absolute). As generalities, they allow exceptions.
Sources: From *BCIV*. See also *FCD, FHC*, and *BDPD*.

Table 1.33. Barbarity, Civilization, and Post-Civilization

- **The Rationalizing Process (at the Level of Culture)**
  - *Barbarity*
    - More mythicizing than rationalizing, relatively speaking
  - *Civilization*
    - More rationalizing than mythicizing, relatively speaking
  - *Post-Civilization*
    - Beyond the dichotomy, subject to existential dialectics

- **The Pacifying Process (at the Level of Society)**
  - *Barbarity*
    - More pillaging than pacifying, relatively speaking
  - *Civilization*
    - More pacifying than pillaging, relatively speaking
  - *Post-Civilization*
    - Beyond the dichotomy, subject to existential dialectics

- **The Stewardizing Process (at the Level of Nature)**
  - *Barbarity*
    - More revering than stewardizing, relatively speaking
  - *Civilization*
    - More stewardizing than revering, relatively speaking
  - *Post-Civilization*
    - Beyond the dichotomy, subject to existential dialectics

- **The Subliming Process (at the Level of the Mind)**
  - *Barbarity*
    - More impulsing than subliming, relatively speaking
  - *Civilization*
    - More subliming than impulsing, relatively speaking
  - *Post-Civilization*
    - Beyond the dichotomy, subject to existential dialectics

---

Notes: The comparison in each category is relative (not absolute), nor are they necessarily mutually exclusive. And some can be easily re-classified elsewhere. As generalities, they allow exceptions.

Sources: From *BCIV*. See also *FHC*, *FCD*, *FPHC*, *BDPD*, and *BCPC*.

Table 1.34. Five Theses on Post-Civilization

- Post-civilization no longer treats civilization as good and barbarity as evil (relatively speaking), nor does it nostalgically regard barbarity as good and civilization as evil (relatively speaking again). Civilization is as evil and good as barbarity.

- Post-civilization also no longer accepts the dichotomy between civilization and barbarity. Civilization cannot exist without barbarity. It is no longer necessary to preserve civilization, any more than it is imperative to destroy barbarity.

- Post-civilization is also subject to the constraints of existential dialectics. There is no freedom without unfreedom, and no equality without inequality, for instance. There will be no utopia; even should there be one, there would be dystopia embedded within it.

- Post-civilization will eventually replace civilization (as a form of life settlement), to be dominated by post-capitalist and post-democratic lifeforms here on earth and in deep space (besides other alien lifeforms that we have never known), unto the post-human age in multiverses. Those few post-humans who keep civilization will live in a "post-human civilization", while the rest (the majority), who choose post-civilization, will evolve towards the state of "post-human post-civilization". One therefore should *not* confuse "post-human civilization" with "post-human post-civilization", as the two are not the same.

- Post-civilization will confront psychosis as a primary problem in the culture of virtuality unto the post-human age, just as civilization has neurosis as a primary one of its own (although both neurosis and psychosis are major problems in both).

Notes: The comparison in each category is relative (not absolute), nor are they necessarily mutually exclusive. And some can be easily re-classified elsewhere. As generalities, they allow exceptions.
Sources: From *BCIV*. See also *FHC*, *FCD*, *FPHC*, *BDPD*, and *BCPC*.

Table 1.35. No Freedom Without Unfreedom in the Civilizing Processes (Part I)

- *The Rationalizing Process (at the Level of Culture)*
  - if freer from the dominance of unreason (as in barbarism) in the civilizing process, then less free from the rationalizing process (be it in the form of the principle of either transcendence or immanence)
  - if freer from the principle of immanence in the rationalizing process, then less free from the inclination to commit terror in the name of reason and the relative underdevelopment of non-reason (e.g., in relation to yoga and meditation)
  - if freer from the principle of transcendence in the rationalizing process, then less free from the relative underdevelopment of reason (e.g., in relation to systematic methodology) and the occurrence of oppression in the name of non-reason

- *The Pacifying Process (at the Level of Society)*
  - if freer from the dominance of pillage (as in savagery) in the civilizing process, then less free from the pacifying process (be it in the form of external control or self-control)
  - if freer from self-control in the pacifying process, then less free from the temptation of expansionist oppression and rebellious mindset in external control
  - if freer from external control in the pacifying process, then less free from the gruesome psychological self-torture and conformism in self-control

---

(continued on next page)

Table 1.35. No Freedom Without Unfreedom in the Civilizing Processes (Part II)

- *The Stewardizing Process (at the Level of Nature)*
  - if freer from the dominance of nature (as in the state of nature) in the civilizing process, then less free from the stewardizing process (be it in the form of the stewardship of creation or the covenant with nature)
  - if freer from the stewardship of creation in the stewardizing process, then less free from material underdevelopment, relatively speaking, and spiritual exclusion in the covenant with nature
  - if freer from the covenant with nature in the stewardizing process, then less free from ecological degradation and spiritual disconnection from nature in the stewardship of creation

- *The Subliming Process (at the Level of the Mind)*
  - if freer from the dominance of spontaneity (as in the wild state of the mind) in the civilizing process, then less free from the subliming process, be it in the form of (cyclical-centric) self-refinement or (linear-centric) self-discipline
  - if freer from (cyclical-centric) self-refinement in the subliming process, then less free from the (linear-centric) self-regimen (as a form of neurosis)
  - if freer from (linear-centric) self-discipline in the subliming process, then less free from the (cyclical-centric) self-torture (equally as a form of neurosis)

Notes: The examples in each category are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they necessarily mutually exclusive. And some can be easily re-classified elsewhere. As generalities, they allow exceptions.
Sources: From *BCIV*. See also *FHC*, *FCD*, *FPHC*, *BDPD*, and *BCPC*.

Table 1.36. No Equality Without Inequality in the Civilizing Processes (Part I)

- *The Rationalizing Process (at the Level of Culture)*
  - if more equal for the role of rationalization in the rationalizing process (of civilizational making), then less equal for that of mythicization (as in barbarism)
  - if more equal for the principle of transcendence in (linear-centric) rationalizing process, then less equal for the principle of immanence
  - if more equal for the principle of immanence in (cyclical-centric) rationalizing process, then less equal for the principle of transcendence

- *The Pacifying Process (at the Level of Society)*
  - if more equal for pacification in civilizational making, then less equal for the institution of pillaging and others (as in savagery)
  - if more equal for external control, relatively speaking, in pacifying process, then less equal for self-control
  - if more equal for self-control, relatively speaking, in pacifying process, then less equal for external-control

- *The Stewardizing Process (at the Level of Nature)*
  - if more equal for stewardship in the stewardizing process (of civilizational making), then less equal for reverent (submissive) existence (as in barbarism)
  - if more equal for the stewardship of creation in (linear-centric) stewardizing process, then less equal for the (cyclical-centric) covenant with nature for harmonious co-existence
  - if more equal for the (cyclical-centric) covenant with nature in the stewardizing process, then less equal for the (linear-centric) stewardship of nature for domination

(continued on next page)

Table 1.36. No Equality Without Inequality in the Civilizing Processes (Part II)

- *The Subliming Process (at the Level of the Mind)*
  - if more equal for the role of reason in the subliming process, then less equal for that of unreason (as in the natural state of wildness)
  - if more equal for the primacy of reason in (linear-centric) subliming process, then less equal for other faculties (e.g., intuition, existential feelings, and analogous thinking) in cyclical-centric one
  - if more equal for the exercise of other faculties (e.g., intuition, existential feelings, and analogous thinking) in cyclical-centric subliming process, then less equal for the role of reason in linear-centric counterpart

---

Notes: The examples in each category are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they mutually exclusive. And some can be easily reclassified elsewhere. As generalities, they allow exceptions.
Sources: From *BCIV*. See also *FHC*, *FCD*, *FPHC*, *BDPD*, and *BCPC*.

Table 1.37. The Theoretical Debate on Space-Time (Part I)

- **Isaac Newton's Absolutist (Substantivist) Theory of Space-Time**
  - space and time are independent from each other. The structure of space-time is $E3 \times E1$ (with the structure of space, P, as the set of spatial locations in a three-dimensional Euclidean space, *E3*, and the structure of time as the set of temporal moments, *T*, in the one-dimensional real time, *E1*).
  - space and time are also independent from the effects of matter and events. The existence of space and time is possible even in a world absent of matter (and, for that matter, even in a world absent of events), as if they were material objects but with their total unchangingness thorough time.

- **Albert Einstein's Relativist Theory of Space-Time**
  - space and time are interchangeable (not absolute), just as matter and energy are equivalent (not independent) with the famous equation, $E = mc^2$ (as in the special theory of relativity in 1905).
  - space-time and matter-energy are also relative in a grand union (as in the general theory of relativity in 1915). Thus, each pair affects the other pair, as "matter 'tells' spacetime how to curve [in a non-Euclidean geometry] and...curved spacetime 'tells' matter how to behave....Space contracts near mass and dilates away from it. Time dilates near mass and contracts away from it....Clocks positioned farther away from the mass of the earth run faster than clocks closer to the earth". (L. Shlain 1991: 328-330)

(continued on next page)

Table 1.37. The Theoretical Debate on Space-Time (Part II)

- **Peter Baofu's Perspectival Theory of Space-Time**
  - space and time can be understood from multiple perspectives, be they in relation to culture, society, nature, and the mind, with each perspective revealing something about the nature of space-time and simultaneously delimiting its view. This is subject to "the regression-progression principle" in existential dialectics.
  - each perspective of space and time exists in society and culture with good reasons, with some being more successful and hegemonic (dominant) than others. This is subject to "the symmetry-asymmetry principle" in existential dialectics.
  - space and time will not last, to be eventually superseded (altered) by post-humans in different forms (e.g., stretching/ shrinking space-time, engineering more dimensions of space-time, and manipulating multiverses), be they here in this universe or in multiverses. Thus, even the physical existence of space-time cannot last forever, with ever more transformations in the process. This is subject to "the change-constancy principle" in existential dialectics.
  - the conventional wisdom (especially by physicists) of treating the physical perspective of space and time as the foundation of all other perspectives (of space and time) and of regarding them as much less important is a form of reductionism, committing what I call *the foundation fallacy*, in misleadingly dismissing the multiple perspectives of space and time in relation to culture, society, nature, and the mind.

Notes: The examples in each category are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they necessarily mutually exclusive. Some can be easily re-classified elsewhere. As generalities, they allow exceptions.

Sources: A summary of *Sec. 1.1*, *Sec. 1.2*, *Sec. 1.3*—and for that matter, the rest of *FPHST*.

Table 1.38. Types of Super Civilization in the Cosmos (Part I)

- **Type I**
  - a civilization which gains control of and uses the total energy output "falling on its planet from its sun for interstellar communication" (or, in general, space colonization). For N. Kardashev, who proposed the first three types, human civilization is currently Type Zero (Type O), which is below even Type I, since its present energy consumption for all purposes, let alone for interstellar communication, is still 10,000 times less.

- **Type II**
  - a civilization which gains control of and uses directly the total energy output of its sun for interstellar communication (or, in general, space colonization).

- **Type III**
  - a civilization which gains control of and uses the total energy output of its galaxy for interstellar communication (or, in general, space colonization).

- **Type IV**
  - a civilization which gains control of and uses the total energy output of its cluster of galaxies for interstellar communication (or, in general, space colonization).

- **Type V**
  - a civilization which gains control of and uses the total energy output of its supercluster of galaxies for interstellar communication (or, in general, space colonization).

- **Type…n**
  - So continues the series in what I call the cyclical progression of hegemony in the cosmos and beyond.

(continued on next page)

Table 1.38. Types of Super Civilization in the Cosmos (Part II)

Notes: The Russian astrophysicist Nikolai Kardashev proposed the first three types of super civilization in terms of total energy output for interstellar communication. (CSM 1979) I extend his argument further to propose Type IV, Type V, Type VI, and Type…n, in the context of my claim about the cyclical progression of hegemony in the cosmos and beyond.
Sources: From *Table 9.4* in *FCD*. See *FHC*, *FCD*, and *FPHC* for more info.

Table 1.39. Main Reasons for Altering Space-Time

- **The Need to Make New Energy-Matter**
  - Ex: manipulating molecular bonds for new materials
  - Ex: creating nanotechnologies on the atomic scale
  - Ex: engineering the atomic nucleus
  - Ex: restructuring most elementary particles
  - Ex: inventing new forms of matter and energy

- **The Need to Create New Space-Time**
  - Ex: creating "warp drive" (as in science fiction) for space travel
  - Ex: creating "pocket universes"

- **The Need to Conquer the Cosmos unto Multiverses**
  - Ex: spreading floating consciousness and hyper-spatial consciousness, besides other forms that humans have never known, in the cosmos and beyond unto multiverses for ultimate conquest

Notes: The examples in each category are solely illustrative (not exhaustive) nor necessarily mutually exclusive, and the comparison is relative (not absolute). As generalities, they allow exceptions. Also, it should be stressed that the three reasons are all related, in that they all contribute to the evolution of intelligent life in the cosmos unto multiverses in the most distant future beyond our current knowledge.
Sources: A summary of *Sec. 6.2* of *FPHST*. See also *FHC*, *FCD*, and *FPHC*.

Table 1.40. Civilizational Holism
(Part I)

- *At the Micro-Physical Theoretical Level*
  - Ex: Mastering of quantum mechanics, electromagnetism, and other fields for the understanding of a broad range of anomalous experiences and the application for artificial intelligence (*Sec. 1.4.1* of *FPHC*)

- *At the Chemical Theoretical Level*
  - Ex: Unprecedented expansion of (and violence to) the mind through ever new forms of drugs (and virtual technologies, for that matter) (Chap. 9 of *FCD*)

- *At the Biological Theoretical Level*
  - Ex: Humans are not biologically equal, on the basis of race, gender, ethnicity, age, and whatnot. (*Sec. 2.6* & Chap. 10 of *FCD*; *BNN*) And post-humans will experience the same fate, in an even more amazing way.

- *At the Psychological Theoretical Level*
  - Ex: Human cognitive impartiality and emotional neutrality are quite limited. (*Secs. 2.4-2.5* of *FCD*)

- *At the Organizational Theoretical Level*
  - Ex: Administrative colonization of deep space, with less legal-formalism in some corners. (Chaps. 9-10 of *FCD*)

- *At the Institutional Theoretical Level*
  - Ex: Both capitalism and democracy will not last, to be superseded by different versions of post-capitalism and post-democracy in after-postmodernity. (Chap. 10 of *FCD*; *BCPC*; *BDPD*)

(continued on next page)

Table 1.40. Civilizational Holism
(Part II)

- *At the Structural Theoretical Level*
  - Ex: Social stratification reappears in ever new forms, also with new causes and new players in the cyclical progression of hegemony. (Chaps. 8-10 of *FCD*; *BWT*)

- *At the Systemic Theoretical Level*
  - Ex: Outerspace expansion: local → regional → global → solar → galactic → clustery… → multiversal (Chap. 9 of *FCD*; *BWT*)
  - Ex: Demographic transition: human extinction, and the rise of post-humans (e.g., cyborgs, thinking machines, thinking robots, genetically altered superior beings, floating consciousness, hyper-spatial consciousness) (Chap. 4 of *FPHC*; Chap. 10 of *FCD*; Chap. 7 of *FHC*)
  - Ex: New technological forces in material sciences, electronic and communication sciences, energy sciences, biosciences, manufacturing and engineering sciences, and space sciences (Chap. 10 of *FCD* & Chap. 7 of *FHC*)
  - Ex: Systematic dominance towards nature for space colonization (Chaps. 9-10 of *FCD*; Chaps. 2 & 7 of *FHC*)

- *At the Cultural Theoretical Level*
  - Ex: The post-human transcendence of freedom and equality (Chap. 10 of *FCD*)
  - Ex: The rise of post-civilization (*BCIV*)

- *At the Cosmological Theoretical Level*
  - Ex: Mastering of dark matter and dark energy, and the exploration of multiverses (Chap. 4 of *FPHC*; Chap. 10 of *FCD*; Chap. 7 of *FHC*)
  - Ex: The rise of post-human space-time (*FPHST*)

(continued on next page)

Table 1.40. Civilizational Holism (Part III)

- *At Other Levels*
  - Ex: Historical: pre-modernity → modernity → postmodernity → after-postmodernity (human distinction, and the rise of post-humans, including floating consciousness) (Chap. 7 of *FHC* & Chap. 10 of *FCD*)

Notes: These examples are solely illustrative (not exhaustive), and some of the items can be reclassified somewhere else. Nor are they always mutually exclusive. Since they are generalities, exceptions are expected. And the comparison is relative, not absolute.

Sources: From *Table 5.1* of *FPHC*—with details from *FHC*, *FCD* and other books of mine

Table 1.41. Theories on Civilizational Holism (Part I)

I. Nature

– *At the Macro-Physical (Cosmological) Theoretical Level*
- Ex: Theory of Existential Dialectics unto Multiverses (Peter Baofu) (*FHC*; *FCD*; *FPHC*; *BDPD*)
- Ex: Dialetic Theory of Complexity (Peter Baofu) (*FC*)
- Ex: Theory of Hyper-Spatial Consciousness (Peter Baofu) (Chap. 4 of *FPHC*)
- Ex: Theory of Floating Consciousness (Peter Baofu) (Chap. 10 of *FCD*; Chaps. 1 & 4 of *FPHC*)
- Ex: Perspectival Theory of Space-Time (Peter Baofu) (*FPHST*)

– *At the Micro-Physical Theoretical Level*
- Ex: Perspectival Theory of Space-Time (Peter Baofu) (*FPHST*)

II. The Mind

– *At the Biological Theoretical Level*
- Ex: Theory of Contrastive Advantages (Peter Baofu) (*Sec. 2.6* & Chap. 10 of *FCD*; *BNN*)

– *At the Psychological Theoretical Level*
- Ex: Theory of Floating Consciousness (Peter Baofu) (Chap. 10 of *FCD*; Chaps. 1 & 4 of *FPHC*)
- Ex: Theory of Cognitive Partiality (Peter Baofu) (*Sec. 2.4* of *FCD*; *Sec. 4.5.1.1* of *BCPC*)
- Ex: Theory of Emotional Non-Neutrality (Peter Baofu) (*Sec. 2.5* of *FCD*; *Sec. 4.5.2* of of *BCPC*)
- Ex: Theory of Behavioral Alteration (Peter Baofu) (*Sec. 4.5.3* of *BCPC*)

(continued on next page)

Table 1.41. Theories on Civilizational Holism (Part II)

III. Society

- *At the Organizational Theoretical Level*
  - Ex: Theory of E-Civic Alienation
    (Peter Baofu) (Chap. 7 of *FCD*)

- *At the Institutional Theoretical Level*
  - Ex: Theory of Post-Capitalism (Peter Baofu)
    (Ch.10 of *FCD*; Chaps. 2 & 4 of *FPHC*; *BCPC*)
  - Ex: Theory of Post-Democracy (Peter Baofu)
    (Ch.10 of *FCD*; Chaps. 3 & 4 of *FPHC*; *BDPD*)

- *At the Structural Theoretical Level*
  - Ex: Theory of the Cyclical Progression of Hegemony
    (Peter Baofu) (Chaps. 9-10 of *FCD*; Chaps. 1, 3 & 4 of *FPHC*)

- *At the Systemic Theoretical Level*
  - Ex: Theory of Post-Humanity (Peter Baofu)
    (Chap. 7 of *FHC*; Chaps. 3 & 10 of *FCD*; Chaps. 1, 3 & 4 of *FPHC*)
  - Ex: Theory of the Cyclical Progression of System Integration and Fragmentation
    (Peter Baofu) (Chaps. 9-10 of *FCD*; *BWT*)
  - Ex: Dialetic Theory of Complexity
    (Peter Baofu) (*FC*)

(continued on next page)

Table 1.41. Theories on Civilizational Holism (Part III)

IV. Culture

– *At the Cultural Theoretical Level*
  - Ex: Theory of Methodological Holism (Peter Baofu) (Chap. 1 of *FCD*; Chap. 1 of *FPHC*; *Sec. 2.1* & *Sec. 2.5* of *BCPC*)
  - Ex: Theory of Post-Civilization (Peter Baofu) (*BCIV*)
  - Ex: Theory of the Trinity of Modernity to Its After-Postmodern Counterpart (Peter Baofu) (*FHC*; Chap. 10 of *FCD*)

V. The Rest

– *At Other Levels (Historical)*
  - Ex: Theory of the Evolution from Pre-Modernity to After-Postmodernity (Peter Baofu) (*FHC*; Chap. 9-10 of *FCD*; *FPHC*)

Notes: All these theories are my constructions, as some of the main contributions of my grant project on civilization and its future. These examples are solely illustrative (not exhaustive), and some of the items can be reclassified somewhere else. Nor are they always mutually exclusive. Since they are generalities, exceptions are expected.
Sources: From *FHC*, *FCD*, *FPHC*, *BDPD*, *BCPC*, *BCIV*, *FPHST*, *BNN*, and *FPHST*

This page intentionally left blank

• PART TWO •

Nature

This page intentionally left blank

• CHAPTER TWO •

Natural Complexity

> [Albert] Einstein was questioning when he said: “I cannot believe that God would choose to play dice with the universe”. [Niels] Bohr, who was one of the authors of the Copenhagen interpretation [of quantum mechanics], responded: “Einstein, don't tell God what to do”.
>
> —“Quantum Mechanics, Philosophy and Controversy”, *AC* (2006)

2.1 The Awe of Nature

The phenomena of complexity can be shown in relation to the awe of the natural world. And the fields of physics and chemistry are two good places to start for this exploration of natural complexity in action—whereas the related fields like biology and psychology overlap with the inquiry about the wonder of the mind in mental complexity (as will be analyzed in Chap. 3) and are therefore postponed for analysis here until the next chapter.

With this organization of the project in mind—it should be stressed that not all events in nature are complex; consequently, only the class of events which can be classified as complex is to be examined hereafter (and for that matter, in the rest of this book).

To classify some events in the class of "complexity", some criteria have to be satisfied. Seth Miller, for instance, came up with "at least 45 different definitions of 'complexity'", but not all of them are relevant in any particular field. (J. Rosser 2003)

Other scholars like David Green (2001) and David Newth for instance, specify some main ones, namely, (a) "self-organization", (b) "connectivity", (c) "criticality", (d) "novelty", (e) "diversity", and (f) "emergence" (as summarized in *Table 2.1*).

(a) Self-organization refers to "a process in which the internal organization of a system, normally an open system, increases in complexity without being guided or managed by an outside source". (WK 2006c)

In a closed system, however, self-organization is normally severely constrained, in accordance to the second law of thermodynamics, "where entropy is envisioned as a measure of the statistical 'disorder' at a microstate level", such that disorder increases over time at the expense of order, when free energy is used up. (WK 2006c)

In an open system, by contrast, order and disorder may not be in contradiction, since "it is possible for a [open] system to reduce its entropy [disorder] by transferring it to its environment" (or, bluntly speaking, by dumping its own waste into the external environment). (WK 2006c)

Thus, "in open systems, it is the flow of matter and energy through the system that allows the system to self-organize, and to exchange entropy with the environment....Ilya Prigogine noted that self-organization can only occur far away from thermodynamic equilibrium. It would appear that, since isolated systems cannot decrease their entropy, only open systems can exhibit self-organization. However, such a system can gain *macroscopic* order while increasing its overall entropy. Specifically, a few of the system's macroscopic degrees of freedom can become more ordered at the expense of microscopic disorder". (WK 2006c)

Self-organization can be identified in terms of some major features, such as (a1) "positive feedback" (i.e., a reinforcing response in the same direction as the original set point when a system undergoes a disturbance), (a2) "negative feedback" (i.e., an undermining response in the opposite direction), (a3) the "balance of exploitation and exploration" (for system sustainability), and (a4) "multiple interactions" (among different units in a system). (WK 2006c & 2006d)

(b) Self-organization is not enough, however. Connectivity is also needed, in that mutual dependencies (or connections) among different objects in a system are well defined in relation to units, interactions, state changes, and neighborhoods, for instance. Any phase change in connectivity, if disruptive enough over time, may eventually lead to an onset of chaos.

(c) Here lies the interesting relationship between criticality and chaos in system change. For instance, at what critical point will chaos finally set in to disrupt a system after a phase change, before it will eventually settle down in a new equilibrium?

Or where is "the edge of chaos", in the parlance of C. Langton (1990), separating the point of order from that of chaos? And where is the "chaotic edge", as D. Green (1994) put it, where such a movement of transition occurs from one point to another?

(d) It is here that the role of chaos is vital for the occurrence of novelty in system change. W. Freeman (1992) thus made an apt remark when he said that "chaos may be an important source of novelty in nature." (D. Green 2001)

But nature seldom opts for optimality (the first best solution) but instead makes use of adequate solutions. Green (2001) thus wrote: "Optimization methods are usually preoccupied with finding the very best solution possible. On the other hand, living organisms usually seek only adequate solutions. A foraging animal, for instance, does not need to find every scrap of food in its territory, just enough to live on".

(e) An important question to ask then concerns the degree of diversity that novelty may bring to a system undergoing a phase change. Is too much change a good thing to have? What is the right amount of diversity?

R. May (1973) argued, contrary to conventional wisdom, that too much diversity in the occurrence of novelty can simply bring a collapse in the system. So, the right balance of viability and diversity remains a crucial question to answer for the stability of complex systems. (D. Green 2001)

(f) But the most fascinating question is of course about the predictability (or unpredictability) of emergence in self-organization over time. Emergence, however, is often confused with self-organization.

While it is true that "self-organizing systems typically (though not always) display emergent properties", "there may be instances of self-organization without emergence and emergence without self-organization....The link between emergence and self-organization remains an active research question". (WK 2006c)

The problem here is that "[f]or a phenomenon to be termed emergent it should generally be unpredictable from a lower level description. At the very lowest level, the phenomenon usually does not exist at all or exists only in trace amounts: it is irreducible. Further, 'emergent' is not always a deeply explanatory label even when it is agreed on: the more complex the phenomenon is, the more intricate are the underlying processes, and the less effective the word emergence is alone. In fact, calling a phenomenon emergent is sometimes used in lieu of a more meaningful explanation". (WK 2006g)

Yet, an interesting property of emergence is that, while it requires novelty and chaos in the process—as shown in (b), (c), (d), and (e)— the end point of it all can be the creation of new order. In this sense, "[s]ystems with emergent properties or emergent structures may appear to defy entropic principles and the second law of thermodynamics, because they form and increase order despite the lack of command and central control. This is possible because open systems can extract information and order out of the environment". (WK 2006g)

But any change of (or disturbance to) a system can have effects to the entire domain in a way not exactly predictable, and this can be done, just to cite three possibilities, by way of (i) a change of the initial conditions in a system (as in chaos theory), (ii) a change of the critical values of a control parameter in a system (as in catastrophe theory), and (iii) a change of the physical environment (as in spatial agent-based modeling)—as will be analyzed in Chap. 4 on societal complexity. (WK 2006e)

With this summary of the main criteria for classifying events in the class of complexity in mind—the chapter here can thus be divided into three sections for a more detailed analysis of complexity, that is, (2.2) complexity and chemistry, (2.3) complexity and micro-physics, and (2.4) complexity and macro-physics (cosmology)—to be discussed respectively hereafter (and summarized in *Table 2.2*).

2.2. Complexity and Chemistry

In chemistry, the phenomenon of complexity reveals the fascinating nature of unpredictability and predictability in natural events.

Two interesting case studies suffice here, namely, (2.2.1) local heating and Bernard convection and (2.2.2) diastereoisomerism and dynamic conformation—to be addressed hereafter, in that order.

2.2.1. Local Heating and Bernard Convection

Unlike the state of equilibrium in closed systems (as in equilibrium thermodynamics), "non-equilibrium systems are a rich source of complexity, emergent behavior and chaos". (M. Leach 2006)

A good illustration concerns the case of heating to excite a system locally (without stirring, however, as will be clear later).

2.2.1.1. *Non-Linear Convection Cells*

For instance, "[i]f a layer of fluid is heated from below, the density at the bottom layer becomes lighter than at the top", since the molecules at the bottom get excited by the heating. (M. Leach 2006)

Yet, over time, the heating produces an interesting emergent property, in that, as shown by Henri Bernard in 1900, there gradually emerged “the appearance of hexagonal cells when instability in the form of convection developed”. (M. Leach 2006; S. Ghorai 2003)

This finding is important for the study of complexity, because “[t]he appearance of Bernard cells is an example of 'order out of chaos'. The local heating causes the emergence of complex nonlinear convection cells which—in an emergent manner—arrange into a regular hexagonal lattice. This situation is exactly analogous to the one dimensional waves of slowing and speeding found on highways at high traffic densities....” (M. Leach 2006)

But if such an emergent order is not wanted, one has to stir the fluid; in other words, “[t]he implication of Bernard convection is that local heating can cause complex emergent behavior. To eliminate such effects it is necessary to stir (turbulently mix) the fluid and make it heterogeneous”. (M. Leach 2006)

Yet, stirring may be easy for a small object to yield heterogeneity, but in nature, such a task is often hard to do. For instance, “[t]he Sun also heats our planet with thermal radiation, but the atmosphere is large and it has a spherical geometry, so it cannot be mixed to homogeneous. On Earth, the Bernard cells present as weather systems”. (M. Leach 2006)

Consequently, it is not so easy to predict weather systems (in this example about the Bernard cells on Earth), even when climates are more predictable, by contrast.

2.2.1.2. *The Challenge of Meteorology*

Yet, some scientists do not agree that weather systems cannot be predicted, albeit not with 100% accuracy. (WK 2006hh)

For instance, “[w]ith the development of powerful new supercomputers like the Earth Simulator in Japan, mathematical modeling of the atmosphere can reach unprecedented accuracy. This is not only due to the enhanced spatial and temporal resolution of the grids employed, but also because these more powerful machines can model the Earth as an integrated climate system, where atmosphere, ocean, vegetation, and man-made influences depend on each other realistically. The goal in global meteorological modeling can be termed Earth System Modeling, with a growing number of models of various processes coupled to each other. Predictions for global effects like Global Warming and El Niño are expected to benefit substantially from these advancements". (WK 2006hh)

More about weather systems will be touched on again in the section on micro-physics, in regard to chaos theory and the butterfly effect.

2.2.2. Diastereoisomerism and Dynamic Conformation

Another good illustration is none other than a well-established observation in chemistry that "[a]s molecular size increases, so does complexity, and emergent new properties appear". (M. Leach 2006)

2.2.2.1. *Complex Chemical Properties*

Good instances include, say, "diastereoisomerism" and "dynamic conformation" as emergent properties.

Diastereoisomerism occurs when "[m]olecules with more than one chiral centre exist as diastereoisomers," which are also known as "diastereomers". (M. Leach 2006)

Diasterreomers are not like the more elementary molecular types, "enantiomers", which are "related to each other by a reflection", in that they are "mirror images of each other" and thus simpler. (WK 2006i)

By contrast, "[d]iasterreomers seldom have the same physical properties" and "are chemically distinguishable in an achiral (non-chiral) environment", since they "have different melting points, different IR spectra, different reaction chemistry as well as different biology". (M. Leach 2006; WK 2006i)

These different properties then yield different molecular structures (molecular conformation) in a novel way, that is, in their "dynamic conformation". And different forms of dynamic conformation can shape different forms of chemical reactivity.

A specific example of diastereomers is “D-aldohexose” sugars. A D-aldohexose, in its difficult structure, “has three variable chiral centres, which leads to a set of eight (2^3) D-diastereomers, each with a unique and distinct melting point, IR and H-NMR spectra, reaction chemistry and biochemistry”. (M. Leach 2006)

When the molecular size and its complicatedness increase, “further degrees of freedom emerge. For example, molecular structure cannot be fully described in terms of bond lengths, three atom [X-Y-Z] bond angles and chiral centre configurations. As illustrated by hydrogen peroxide, HOOH…, the four atom dihedral angle emerges as an ever more important parameter….” (M. Leach 2006)

In this example of larger and more complicated molecules, “[v]ariations in dihedral angle lead to conformational isomers”, just as “variations in dihedral angle with time lead to rotormers and dynamic molecular structures”. (M. Leach 2006)

Now, “emergent behavior is hard to predict”, since “the number of interactions between components of a system increases combinatorially with the number of components, thus potentially allowing for many new and subtle types of behavior to emerge. For example, the possible interactions between groups of molecules grows enormously with the number of molecules such that it is impossible for a computer to even count the number of arrangements for a system as small as 20 molecules”. (WK 2006g)

It is no wonder for Mark Leach (2006) to argue that “[a]s molecular structures grow in size and complexity, emergent properties…become ever more important….Chemistry is—and will remain—an experimental science because predictions can seldom be made from first principles”.

2.2.2.2. *The Search for Application*

Yet, this does not prevent some chemists from making some good use of the understanding of complex chemical properties.

Perhaps a good illustration is none other than the fabrication of new drugs in the pharmaceutical industry by way of applying the understanding of emergent chemical properties like dynamic conformation.

For instance, "[t]hese days much drug discovery research involves modelling how substrate molecules and synthetic agonists and antagonists interact with and effect the active site, a process that involves understanding the conformation(s) and dynamic conformational changes adopted by molecules while in or bound to the active site. An example of the software available to pharma industry scientists is Omega by OpenEye Scientific Software. Omega is able to 'generate multi-conformer structure databases so that conformational expansion of drug-like molecules can be performed'". (M. Leach 2006)

2.3. Complexity and Micro-Physics

In micro-physics, complexity takes a different expression in regard to the interaction between order and chaos.

An excellent illustration is none other than scientific research in the field of micro-physics (unlike macro-physics on cosmology, which will be dealt with in the next section instead).

Two case studies can be presented hereafter, that is, (2.3.1) subatomic particles and probability distributions and (2.3.2) weather systems and the butterfly effect—in that order.

2.3.1. Subatomic Particles and Probability Distributions

Quantum mechanics is highly interesting here, since its findings are counter-intuitive to the human mind in everyday life.

In everyday life, it is part of conventional wisdom that every observable has a definite value attached to it, be it about "a definite position, a definite momentum, and a definite time of occurrence". (WK 2006j) Or in physics, every observable in everyday life has an "eigenstate" (with *eigen* meaning "own" in German) of a given property to be measured.

But at the subatomic level, something non-intuitive occurs, in that the properties (say, both position and momentum) of a particle cannot be both measured with a definitive value at the same time. Here lies the importance of W. Heisenberg's *Uncertainty Principle*.

2.3.1.1. *The Uncertainty Principle*

More formally, the "Uncertainty Principle of quantum mechanics states that both the position and the momentum cannot simultaneously be known with infinite precision at the same time". (WK 2006j & 2006k)

In this sense, "quantum mechanics does not assign definite values to observables. Instead, it makes predictions about probability distributions; that is, the probability of obtaining each of the possible outcomes from measuring an observable". (WK 2006j)

So, even in the most ideal situation, one can no longer "pinpoint the exact values for the position or momentum of a certain particle in a given space in a finite time, but, rather,...only provides a range of probabilities of where that particle might be". (WK 2006j)

Just consider a simple example: a free particle. At the subatomic level, particles can have the dual wave-particle properties. So, the properties of the free particle "can be described as a wave. Therefore, its quantum state can be represented as a wave, of arbitrary shape and extending over all of space, called a wavefunction". (WK 2006j)

Now, "[i]f we perform a position measurement on such a wavefunction, we will obtain the result x with 100% probability. In other words, we will know the position of the free particle. This is called an eigenstate of position". (WK 2006j)

But the tradeoff is that "[i]f the particle is in an eigenstate of position then its momentum is completely unknown. An eigenstate of momentum, on the other hand, has the form of a plane wave. It can be shown that the wavelength is equal to h/p, where h is Planck's constant and p is the momentum of the eigenstate". (WK 2006j)

On the other hand, of course, if the eigenstate of momentum of the free particle is known, its position is of uncertain state: "If the particle is in an eigenstate of momentum then its position is completely blurred out". (WK 2006j)

The word "uncertainty" in the Uncertainty Principle is therefore suggestive. The emergent events at the sub-atomic level are not always exactly predictable, without some trade-offs.

2.3.1.2. *The Bohr-Einstein Debate*

Even here, there are deep disagreements among physicists, and a most famous debate involves Einstein, who, as shown in the quotation at the beginning of this chapter in his disagreement with Niels Bohr (and for that matter, W. Heisenberg), never really accepted fully the validity of quantum mechanics.

For instance, for Einstein, "all previously known probability distributions arose from deterministic events. The distribution of a flipped coin or a rolled die can be described with a probability distribution (50% heads, 50% tails), but this does not mean that their physical motions are unpredictable. Ordinary mechanics can be used to calculate exactly how each coin will land, if the forces acting on it are known. And the heads/tails distribution will still line up with the probability distribution (given random initial forces)". (WK 2006k)

Therefore, Einstein then thought "that there are similar hidden variables in quantum mechanics which underlie the observed probabilities and that these variables, if known, would show that there was what Einstein termed —'local realism', a description opposite to the uncertainty principle, being that all objects must already have their properties before they are observed or measured". (WK 2006k)

Interestingly, John Bell in 1964 proposed the Bell's theorem to show that there are no hidden variables to be discovered. His reasoning is straightforward: "[If] the behavior of an individual particle is random, it is also correlated with the behavior of other particles. Therefore, if the uncertainty principle is the result of some deterministic process in which a particle has *local realism*, it must be the case that particles at great distances instantly transmit information to each other to ensure that the correlations in behavior between particles occur". (WK 2006k)

In other words, Bell's theorem "prevents any local hidden variable theory from holding true because it shows the necessity of a system to describe correlations between objects. The implication is, if a hidden local variable is the cause of particle 1 being at a position, then a second hidden local variable would be responsible for particle 2 being in its own position—and there is no system to correlate the behavior between them".

So far, there is still no such correlation to be found. Yet, the debate has not been resolved, since Bell's theorem does not exclude hidden variables at the non-local level: "It is worth noting that Bell's theorem only applies to local hidden variable theories; non-local hidden variable theories can still exist...." (WK 2006k)

Thus, the debate continues to our day.

2.3.2. Weather Systems and the Butterfly Effect

Another way to look into the messy problem of predictability in the field of natural complexity is the seminary work by Edward Lorenz in 1960, in what became later known as "chaos theory". (G. Rae 2006)

2.3.2.1. *An Advance in Chaos Theory*

It all started with an interesting anecdote about Edward Lorenz' s well-known meteorological experiment: "In 1960, he was working on the problem of weather prediction. He had a computer set up, with a set of twelve equations to model the weather. It didn't predict the weather itself. However this computer program did theoretically predict what the weather might be. One day in 1961, he wanted to see a particular sequence again. To save time, he started in the middle of the sequence, instead of the beginning. He entered the number off his printout and left to let it run". (G. Rae 2006)

To his amazement, when he returned to the lab later, he discovered a different sequence altogether: "Instead of the same pattern as before, it diverged from the pattern, ending up wildly different from the original. Eventually he figured out what happened. The computer stored the numbers to six decimal places in its memory. To save paper, he only had it print out three decimal places. In the original sequence, the number was 0.506127, and he had only typed the first three digits, 0.506". (G. Rae 2006)

What Lorenz later realized is that a tiny change in the initial conditions of a system could drastically change its outcomes, which was contrary to the conventional view at the time that tiny changes could not make much of a difference to the outcomes.

When translated into his work on weather prediction, Lorenz proposed something truly unconventional, in relation to what was later known as "the butterfly effect", in that "[t]he amount of difference in the starting points of the two curves is so small that it is comparable to a butterfly flapping its wings". (G. Rae 2006)

Or, as Ian Steward (1989: 141) put it, "[t]he flapping of a single butterfly's wing today produces a tiny change in the state of the atmosphere. Over a period of time, what the atmosphere actually does diverges from what it would have done. So, in a month's time, a tornado that would have devastated the Indonesian coast doesn't happen. Or maybe one that wasn't going to happen, does".

In other words, "[t]his phenomenon, common to chaos theory, is also known as sensitive dependence on initial conditions. Just a small change in the initial conditions can drastically change the long-term behavior of a system. Such a small amount of difference in a measurement might be considered experimental noise, background noise, or an inaccuracy of the equipment....From this idea, Lorenz stated that it is impossible to predict the weather accurately". (G. Rae 2006)

Yet, Lorenz later discovered something more refined, in that there can be some emergent order to be discovered (even if not exactly predictable) in the midst of chaos.

For instance, "Lorenz started to look for a simpler system that had sensitive dependence on initial conditions....He took the equations for convection, and stripped them down, making them unrealistically simple. The system no longer had anything to do with convection, but it did have sensitive dependence on its initial conditions, and there were only three equations this time. Later, it was discovered that his equations precisely described a water wheel". (G. Rae 2006)

James Gleick (1988: 29) nicely described how the water wheel worked: "At the top, water drips steadily into containers hanging on the wheel's rim. Each container drips steadily from a small hole. If the stream of water is slow, the top containers never fill fast enough to overcome friction, but if the stream is faster, the weight starts to turn the wheel....Or if the stream is so fast that the heavy containers swing all the way around the bottom and up the other side, the wheel might then slow, stop, and reverse its rotation, turning first one way and then the other".

But in spite of all the possibilities about how the wheel may behave, Lorenz discovered that its behavior followed a spiral shape over a long period of time: "The output always stayed on a curve, a double spiral. There were only two kinds of order previously known: a steady state, in which the variables never change, and periodic behavior, in which the system goes into a loop, repeating itself indefinitely. Lorenz's equations were definitely ordered—they always followed a spiral. They never settled down to a single point, but since they never repeated the same thing, they weren't periodic either. He called the image he got when he graphed the equations the Lorenz attractor". (G. Rae 2006)

In the end, a good way to summarize here is that "the Lorenz system pictured is chaotic, but has a clearly defined structure. Weather is chaotic, but its statistics—climate—is not". (WK 2006p)

2.3.2.2. *The Fad of Chaos Theory*

Yet, chaos theory is not without its limits, as John Horgan (1995) rightly criticized it as a fad in the 1980's, with its predecessors like cybernetics (hot in the 1960s) and catastrophe theory (hot in the

1970s)—but now, complexity theory is fast becoming a new fad since the 1990's, dethroning chaos theory. (J. Rosser 2003)

As an illustration, it is no longer adequate nowadays to look into the change of the initial conditions in a system (as in chaos theory).

Other changes are deemed important to be considered too, and two good instances are the change of the critical values of a control parameter in a system (as in catastrophe theory) and the change of the physical environment (as in spatial agent-based modeling)—as will be analyzed in Chap. 4 on societal complexity. (WK 2006e)

2.4. Complexity and Macro-Physics (Cosmology)

The phenomenon of complexity in macro-physics is not less fascinating, especially when it deals with the larger inquiry about order and chaos in the cosmos.

Two good case studies concern, for example, (2.4.1) galaxy large-scale structures and their fractal distributions and (2.4.2) chaotic inflation and the Big Bang—to be illustrated below, respectively.

2.4.1. Galaxy Clustering and Fractal Distributions

Galaxy large-scale structures are interesting in shedding some light on the nature of complexity in macro-physics.

2.4.1.1. *Fractal vs. Guassian Distributions*

A good case study is about galaxy large-scale structures and their fractal distributions (which are different from the Gaussian ones; therefore, the Central Limit Theorem for the well-known Bell Curve in normal distributions does not apply here).

In the older days, conventional wisdom in astrophysics has it that the "existence of large scale structures (LSS) and voids in the distribution of galaxies up to several hundreds Megaparsecs" has a homogeneous distribution, usually at very small length scale λ_o. (F. Labini 2001)

A *parsec* in the measurement is "a unit of measure for interstellar space that is equal to 3.26 light-years and is the distance to an object having a parallax of one second as seen from points separated by one astronomical unit", and Megaparsecs are one million parsecs. (MWD 2006)

So, the universe was treated as having a homogenous structure, with only "small fluctuations about a finite average density".

But new research suggests that the picture is more complex than this, with possible large fluctuations in some (fractal) systems and small fluctuations in other (homogeneous) ones. In other words, galaxy structures can have less than homogeneous properties, with some fractal (non-Guassian) distributions, such that "the average density in finite samples is not a well defined quantity: it is strongly sample-dependent going to zero in the limit of an infinite volume". (F. Labini 2001)

New data collection now shows that "there is a general agreement about the fact that galactic structures are fractal up to a distance scale of $\lambda_0 \approx 30 \div 50h^{-1}$ Mpc". (F. Labini 2001)

One theoretical implication here for the study of complexity is that it challenges the conventional view about "the evolution of density fluctuations within an analytic Gaussian framework, while the non-analyticity of fractal fluctuations implies a breakdown of the central limit theorem which is the cornerstone of Gaussian processes". (F. Labini 2001)

In fact, many of these studies on galaxy large-scale structures and their fractal distributions also reveal the properties of self-organization and criticality, for example, as part of the criteria to understand the class of complexity: "Most of the scale free phenomena observed in nature are self-organized, in the sense that they spontaneously develop from the generating dynamical process". (F. Labini 2001)

2.4.1.2. *An Unanswered Question*

Then, of course, the more difficult question is, Why?

In other words, "the fact that certain structures exhibit fractal and complex properties does not tell us why this happens". (F. Labini 2001)

While no one knows completely why in regard to galaxy large-scale structures and their fractal distributions, a recent advance in cosmology (as shown below) may heat up the debate once more.

2.4.2. Chaotic Inflation and the Big Bang

Although cosmologists have tried to explain why the galaxies formed in the way that they did, the debate is not yet conclusive.

2.4.2.1. *A History of Three Cosmological Theories*

A good illustration here is the brief history of cosmology in relation to three theories to question our understanding of the beginning of the universe, also known as the Big Bang.

The three theories are, namely, (2.4.2.1.1) classical inflationary theory, (2.4.2.1.2) new inflationary theory, and (2.4.2.1.3) chaotic inflationary theory—to be summarized in what follows, in that order.

2.4.2.1.1. Classical Inflationary Theory

In the standard theory of the Big Bang, the universe started with as "a rapidly expanding fireball...in terms of a hot, energetic explosion that took place about 15 billion years ago. The theory has been extremely successful in explaining many aspects of the visible universe. It can account for astronomers' discovery that the universe is expanding. It also explains the discovery in the 1960s that a faint and remarkably uniform microwave signal, called the cosmic background radiation, emanates from everywhere in the heavens. This signal has been interpreted as fossil radiation that dates back to a period when the universe was about 300,000 years old, the point when the primordial mixture of subatomic particles and radiation cooled to the point that light could travel freely". (D. Salisbury 1999)

The first step to challenge this view about the Big Bang is known as the classical "inflationary theory", which raises questions which the standard model of the Big Bang does not answer, such as "Where did the big bang come from, and what preceded it?" "Why does the visible universe, which is about 11 billion light years across, appear to be flat rather than curved?" And "[w]hy is the matter in the universe distributed extremely evenly at a very large scale, yet gathered into large clumps called galaxies at a smaller scale?" (D. Salisbury 1999)

Classical inflationary theory, as worked out by Alexei A. Starobinsky of the L. D. Landau Institute of Theoretical Physics in Moscow in 1979, instead proposes that "the primordial universe underwent a period of rapid, exponential expansion....During a period shorter than an eye blink..., a microscopic speck of space would have expanded explosively until it was much larger than the visible universe". (D. Salisbury 1999)

In so doing, the classical inflationary theory has some advantages over the standard model of the Big Bang: "Two of the benefits of this theory are immediately apparent. At a very large scale, matter is spread out with remarkable uniformity, departing from perfect homogeneity by less than one part in 10,000. If the visible universe started from a single, tiny volume, this extreme uniformity makes perfect sense. Inflationary theory also predicts that the visible universe should be flat, rather than curved, as suggested by Einstein's theory of general relativity. That is because the inflating universe acts similarly to an expanding balloon. If you pick a small area on the surface of a balloon and then blow it up, the area becomes flatter and flatter. Recent astronomical observations suggest that the universe is as flat as inflationary theory predicts". (D. Salisbury 1999)

But the problem here is that the theory still "did not say much about how inflation could actually start". (D. Salisbury 1999)

2.4.2.1.2. New Inflationary Theory

Some astrophysicists then proposed a new inflationary theory to replace the old one.

For instance, in 1972, Andrei Linde and David Kirzhnits at the P. N. Lebedev Physics Institute in Moscow "suggested that the early universe went through a series of phase transitions. As the universe expanded and cooled, it condensed into different forms, much like water vapor becomes liquid water that freezes into ice. In 1981, Alan H. Guth at Massachusetts Institute of Technology [M.I.T.] built on this idea by suggesting that the universe might have gone through an unstable, super-cooled state during which the universe would undergo exponential expansion. Super-cooling is common during phase transitions. For example, undisturbed water can be cooled below 32 degrees Fahrenheit. But the slightest disturbance causes it to freeze rapidly". (D. Salisbury 1999)

So, a theoretical insight here is that a slight change in the system can produce drastic outcomes for complex phenomena to emerge.

But the problem with the new inflationary theory is that it did not explain the nature of the situation before the cosmological inflation; in fact, it simply assumed "a false vacuum" to refer to "a state without any particles, but with a lot of potential energy". (D. Salisbury 1999)

As Andrei Linde explained, "[t]he problem with this idea is that this completely symmetric and nice state is so empty that you do not have any preferable coordinate system". (D. Salisbury 1999)

So, this "means there is no way to determine whether the universe is expanding or not and, if you cannot make that determination, then the expansion is not real; instead it is a 'false expansion'". (D. Salisbury 1999) The notion of a false vacuum was dead when "[a]fter exploring his idea for a year, Guth concluded that it could not work". (D. Salisbury 1999)

But Linde proposed a fix in 1982, in what is now known as the "new inflationary theory", that is, "by showing that inflation can take place in a false vacuum state that has begun to deteriorate. A few months later the same idea was proposed by Andreas Albrecht and Paul Steinhardt at the University of Pennsylvania". (D. Salisbury 1999) Linde thus elaborated: "If you have just a little bit of change, then you can have this preferable system that tells you when it is expanding". (D. Salisbury 1999)

New inflationary theorists then proposed the idea of "a scalar field" or "the inflation field" to describe "the energy in this near-false-vacuum state....There is no exact comparison to such a field in nature today. But an electrostatic field, like that generated by the static build-up in clothes that causes them to cling, is a close analogy. A uniform electrostatic field is virtually undetectable: It only generates electrical and magnetic fields when it is inhomogeneous or changes over time. The inflation field has the same basic characteristics but differs in one important way: It carries its own energy". (D. Salisbury 1999)

In accordance to this theory, "when the inflation field began falling, the primordial universe could undergo real, exponential inflation rather than false inflation. An imaginary observer equipped with a gravity meter would begin recording a slight weakening in the force of gravity and, if she were able to mark two different positions in nearby space, she would see them begin flying apart. As the scalar field decreases, it undergoes a phenomenon called quantum fluctuations. They are predicted by quantum electrodynamics, the laws that explain the behavior of subatomic particles. Initially, these oscillations would be sub-microscopic in scale. But as space inflates they become larger and larger, until they become the size of galaxies. Because these fluctuations correspond to variations in energy density, when the period of inflation ends, larger amounts of matter would be produced in areas where the field is high than in regions where it is low. Thus, they can explain the formation of galaxies". (D. Salisbury 1999)

The beauty of the new inflationary theory is that it can answer some questions that the previous one could not. For instance, "[t]he mechanism [of the inflation field with quantum fluctuations] is also consistent with the discovery of slight variations in the strength of the cosmic background radiation discovered in 1992. They are also interpreted as the product of quantum fluctuations in the glowing soup of matter and energy. They are much smaller because they occurred before the universe finished its period of exponential expansion". (D. Salisbury 1999)

But the new theory has some problematic assumptions, since it does not explain why "the universe began both hot and in thermal equilibrium, that is, at the same temperature everywhere.

Then inflation took place and all the original particles were swept away in the extraordinary growth spurt. At the end of the inflationary period, particles were recreated and then reheated by the fluctuating scalar field". (D. Salisbury 1999)

As Linde critically asked, "What evidence is there that the universe was originally hot? What evidence is there that it was in thermal equilibrium? None at all". (D. Salisbury 1999)

2.4.2.1.3. Chaotic Inflationary Theory

A latest version is called "chaotic inflationary theory", since it makes use of the chaotic state as the beginning of the universe (without assuming that the universe was initially hot), so that "the big bang remains but becomes an aftereffect of cosmic inflation", and an important assumption is simply that "a universe like our own is a patch of primordial universe with a large scalar field that is moving toward its minimum value". (D. Salisbury 1999)

Linde thus explained: "If the scalar field falls down very slowly, it is nearly indistinguishable from a false vacuum and the universe will inflate". (D. Salisbury 1999) This means that some regions do not inflate, while others do: "Some regions do not inflate. But that just means they become insignificant. The parts that can undergo inflation, on the other hand, become huge and most of the volume of the universe comes from them". (D. Salisbury 1999)

In the end, chaotic inflation simply means that, as Linde summarized, it "creates order out of chaos, not by destroying previous chaos, but by exploding those parts that are capable of becoming non-chaotic".

A logical extension of chaotic inflationary theory is the idea of an "eternally self-reproducing universe", and the reason is that "in very rare instances, quantum fluctuations would cause the field to jump up in some parts of the universe. These places would be extremely rare. When the inflation field increases, however, some of these sites would begin inflating madly. In almost no time, they grow into very large regions with high scalar fields. Then, within these inflated regions, the process repeats itself. Quantum fluctuations strike again, causing the field strength to jump in a few localities, some of which undergo a second round of inflation. And so on, ad infinitum". (D. Salisbury 1999)

2.4.2.2. *Some Critical Questions*

The main problem with chaotic inflationary theory, however, is that it raises some critical questions, just as it tries to answer some which were not answered in old theories which it wants to dethrone.

For instance, why was there the inflation field at the beginning of the universe, together with all its quantum fluctuations, in a chaotic state? In fact, chaotic inflationary theory may commit the same sin in making an unquestioned assumption—just as the classical inflationary theory held its own version in falsely assuming that the universe was hot at the beginning.

Does chaotic inflationary theory therefore falsely assume, albeit in a different way, that the universe was chaotic at the beginning? Or, why was the universe chaotic at the beginning in accordance to quantum electrodynamics—just as Linde once asked why the universe must be hot at the beginning, only to discover that it did not need to be so at all?

2.5. The Perplexity of Natural Complexity

But this only suggests some unpredictability in nature, which still evades the brightest and most brilliant minds in the natural sciences to date.

And the study of complexity in nature serves as a case study (which is summarized in *Table 2.2*) to reveal the interactions of order and chaos in a way which is complex enough to puzzle us.

But nature is not the only thing there be. There are also the mind, society, and culture, for example. Let's now turn to the second consideration, that is, of the mind in the next chapter in what follows.

Table 2.1. Main Criteria for Complex Events (Part I)

- **Self-Organization**
  - Self-organization refers to "a process in which the internal organization of a system, normally an open system, increases in complexity without being guided or managed by an outside source". (WK 2006c) See also David Green (2001) for the criteria.
  - In a closed system, however, self-organization is normally severely constrained, in accordance to the second law of thermodynamics, "where entropy is envisioned as a measure of the statistical 'disorder' at a microstate level", such that disorder increases over time at the expense of order, when free energy is used up. (WK 2006c)
  - In an open system, by contrast, order and disorder may not be in contradiction, since "it is possible for a [open] system to reduce its entropy [disorder] by transferring it to its environment" (or, bluntly speaking, dumping its own waste into the external environment). (WK 2006c)
  - Self-organization can be identified in terms of some major features, such as (a1) "positive feedback" (i.e., a reinforcing response in the same direction as the original set point when a system undergoes a disturbance), (a2) "negative feedback" (i.e., an undermining response in the opposite direction), (a3) the "balance of exploitation and exploration" (for system sustainability), and (a4) "multiple interactions" (among different units in a system). (WK 2006c & 2006d)

- **Connectivity**
  - Connectivity is also needed, in that mutual dependencies (or connections) among different objects in a system are well defined in relation to units, interactions, state changes, and neighborhoods, for instance. Any phase change in connectivity, if disruptive enough over time, may eventually lead to an onset of chaos.

(continued on next page)

Table 2.1. Main Criteria for Complex Events (Part II)

- **Criticality**
  - Here lies the interesting relationship between criticality and chaos in system change. For instance, at what critical point will chaos finally set in to disrupt a system after a phase change, before it will eventually settle down in a new equilibrium?
  - Or where is "the edge of chaos", in the parlance of C. Langton (1990), separating the point of order from that of chaos? And where is the "chaotic edge", as D. Green (1994) put it, where such a movement of transition occurs from one point to another?

- **Novelty (in Chaos)**
  - It is here that the role of chaos is vital for the occurrence of novelty in system change. W. Freeman (1992) thus made an apt remark when he said that "chaos may be an important source of novelty in nature". (D. Green 2001)
  - But nature seldom opts for optimality (the first best solution) but instead makes use of adequate solutions. Green (2001) thus wrote: "Optimization methods are usually preoccupied with finding the very best solution possible. On the other hand, living organisms usually seek only adequate solutions. A foraging animal, for instance, does not need to find every scrap of food in its territory, just enough to live on".

(continued on next page)

Table 2.1. Main Criteria for Complex Events (Part III)

- **Diversity**
  - An important question to ask then concerns the degree of diversity that novelty may bring to a system undergoing a phase change. Is too much change a good thing to have? What is the right amount of diversity?
  - R. May (1973) argued, contrary to conventional wisdom, that too much diversity in the occurrence of novelty can simply bring a collapse in the system. So, the right balance of viability and diversity remains a crucial question to answer for the stability of complex systems. (D. Green 2001)

- **Emergence**
  - But the most fascinating question is of course about the predictability (or unpredictability) of emergence in self-organization over time.
  - The problem here is that "[f]or a phenomenon to be termed emergent it should generally be unpredictable from a lower level description. At the very lowest level, the phenomenon usually does not exist at all or exists only in trace amounts: it is irreducible. Further, 'emergent' is not always a deeply explanatory label even when it is agreed on: the more complex the phenomenon is, the more intricate are the underlying processes, and the less effective the word emergence is alone". (WK 2006g)
  - Yet, an interesting property of emergence is that, while it requires novelty and chaos in the process, the end point of it all can be the creation of new order.
  - But any change of (or disturbance to) a system can have effects to the entire domain in a way not exactly predictable, for instance, by way of (i) a change of the initial conditions (as in chaos theory), (ii) a change of the critical values of a control parameter (as in catastrophe theory), and (iii) a change of the physical environment (as in spatial agent-based modeling).

(continued on next page)

Table 2.1. Main Criteria for Complex Events (Part IV)

Notes: The examples in each category are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they necessarily mutually exclusive. Some can be easily re-classified elsewhere. As generalities, they allow exceptions.

Source: A summary of *Sec. 2.1* of *FC*

Table 2.2. Natural Complexity

- **Complexity and Chemistry**
  - Ex: Local heating and Bernard convection
  - Ex: Diastereoisomerism and dynamic conformation

- **Complexity and Micro-Physics**
  - Ex: Subatomic particles and probability distributions
  - Ex: Weather systems and the Lorenz attractor

- **Complexity and Macro-Physics (Cosmology)**
  - Ex: Galaxy clustering and fractal distributions
  - Ex: Chaotic inflation and the Big Bang

Notes: The examples in the categories are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they necessarily mutually exclusive. And some can be easily re-classified elsewhere. As generalities, they allow exceptions.

Source: A summary of Chap. 2 of *FC*

This page intentionally left blank

• Part Three •

The Mind

• CHAPTER THREE •

Mental Complexity

> The reality is that in order to reach a general equilibrium with large numbers of [inputs for analysis]..., individuals would need brains with far more computing power than they currently have, and even then individuals would need to spend all their time processing info so they could remain rational.
>
> —David Colander (1994)

3.1. The Wonder of the Mind

The phenomenon of complexity has its exotic manifestation in the domain of life and intelligence—just as it reveals its fascinating impact on the natural world of chemistry and physics (as already discussed in Chap. 2 on natural complexity).

In a way, this chapter is also related to the previous one, since one cannot completely separate mental complexity from natural complexity.

Yet, for academic convenience, a separate chapter can be devoted more fully to the inner workings of biology and psychology in mental complexity, or more specifically, in relation to (3.2) complexity and biology and (3.3) complexity and psychology—in what follows, respectively.

The analysis is also summarized in *Table 3.1*.

3.2. Complexity and Biology

The very fundamental inquiry about the origins of life and intelligence remains to this day one of the most complex issues yet to be completely understood.

Consider two main questions in biology (and related fields too), that is, about (3.2.1) the evolution of life and (3.2.2) the evolution of language.

They can be used here as two case studies in biology—or more precisely, evolutionary biology, together with other related fields—and complexity, to be discussed respectively hereafter.

3.2.1. The Evolution of Life, and Autocatalytic Set

The first central question touches the very core of the phenomenon concerning the interaction between biology and complexity and can be rephrased in a different way, namely, How exactly does life emerge with the combination of some molecules?

Put in this way, it is not difficult to understand that "[p]rogress in this field is generally slow and sporadic, though it still draws the attention of many due to the eminence of the question being investigated. A few facts give insight into the conditions in which life may have emerged, but the mechanisms by which non-life became life are still elusive". (WK 2006l)

A good starting point concerns the idea of "autocatalytic set" to study the origin of life as a case study of complexity in action in relation to life and intelligence.

The term "autocatalytic set" refers to "a collection of entities, each of which can be created catalytically by other entities within the set, such that as a whole, the set is able to catalyze its own production. In this way the set as a whole is said to be autocatalytic". (WK 2006m)

Autocatalytic sets are related to the idea of self-organization as a central criterion for the class of complex events (as already analyzed in Chap. 2), since they are "able to replicate themselves if they are split apart into two physically separated spaces....This property is why autocatalysis is a contender as the foundational mechanism for complex evolution". (WK 2006m)

In the early history of biology, that is, "[p]rior to Watson and Crick, biologists considered autocatalytic sets the way metabolism functions in principle, i.e. one protein helps to synthesize another protein and so on. After the discovery of the double helix, the central dogma of genetics was formulated, which is that DNA is transcribed to RNA which is translated to protein. The molecular structure of DNA and RNA, as well as the metabolism that maintains their reproduction, are believed to be too complex to have arisen spontaneously in one step from a soup of chemistry". (WK 2006m)

So now, it is well accepted that life is too complex to be originated from a primitive molecule in a soup of chemistry working its way up to an advanced one but from a complex form of autocatalytic set.

3.2.1.1. *Earth-Centric and Extra-Terrestrial Models*

There have been different models of the origin of life to work out the details of this evolution, but none is widely accepted in the community of biologists.

There are, however, two distinct approaches to be mentioned here for illustration, namely, (3.2.1.1.1) the first is earth-centric and (3.2.1.1.2) the second is extra-terrestrial.

3.2.1.1.1. Earth-Centric

The first approach which has fascinated many biologists is earth-centric, in focusing on the early pre-biotic environment of Earth as a starting point of the enquiry.

For instance, Stanley Miller in 1953 conducted a simulation of "the prebiotic atmosphere of Earth" by using "a highly reduced mixture of gases (methane, ammonia and hydrogen)" in his experiment, which "showed that some of the basic organic monomers (such as amino acids) that form the polymeric building blocks of modern life can be formed spontaneously". (WK 2006l)

But the critics were quick to point out that "[s]imple organic molecules are of course a long way from a fully functional self-replicating life form....[Besides], the spontaneous formation of complex polymers from abiotically generated monomers under these conditions is not at all a straightforward process". (WK 2006l)

Since then, there are many different models to replace the one by Miller, but none is widely accepted. A few examples include, solely for illustration, Manfred Eigen's hypothesis of "a self replicating hypercycle" (i.e., the transition "between the molecular chaos in a prebiotic soup and simple macromolecular self-reproducing systems") and Günter Wächtershäuser's "iron-sulfur world theory" (i.e., "the evolution of...bio...chemical pathways as fundamentals of the evolution of life..., tracing today's biochemistry back to ancestral reactions that provide alternative pathways to the synthesis of organic building blocks from simple gaseous compounds"). (WK 2006l)

3.2.1.1.2. Extra-Terrestrial

The second approach, by contrast, points to places beyond Earth for possible explanation. (L. Lin 2006; S. Clark 2002; WK 2006l)

Researchers following this approach look instead into "complex molecules...of extra-terrestrial stellar or interstellar origin. For example, from spectral analyses, organic molecules are known to be present in comets and meteorites. In 2004, a team detected traces of polycyclic aromatic hydrocarbons (PAH's) in a nebula, the most complex molecule, to that date, found in space". (WK 2006l)

The reason for the appeal of this second approach is that "[o]rganic compounds are relatively common in space, especially in the outer solar system where volatiles are not evaporated by solar heating. Comets are encrusted by outer layers of dark material, thought to be a tar-like substance composed of complex organic material formed from simple carbon compounds after reactions initiated mostly by irradiation by ultraviolet light. It is supposed that a rain of material from comets could have brought significant quantities of such complex organic molecules to Earth". (WK 2006l)

Some researchers who favor this approach have come up with a different model, this time, with a specific target in mind: that is, Mars as the best candidate, to suggest that "life formed first on early Mars". (WK 2006l) Why so?

The explanation is that "[d]ue to its smaller size Mars cooled before Earth (a difference of hundreds of millions of years), allowing prebiotic processes there while Earth was still too hot. Life was then transported to the cooled Earth when crustal material was blasted off Mars by asteroid and comet impacts. Mars continued to cool faster and eventually became hostile to the continued evolution or even existence of life (it lost its atmosphere due to low volcanism), Earth is following the same fate as Mars, but at a slower rate". (WK 2006l)

3.2.1.2. *Begging the Question Somehow*

Yet, in either way (i.e., targeting Mars or the Earth), none of them really answers the essential question of "how life first originated...." (WK 2006l)

But this is not to say that they are useless. For instance, in accordance to the second (extra-terrestrial) approach, "the advantage of an extraterrestrial origin of primitive life is that life is not required to have evolved on each planet it occurs on, but rather in a single location, and then spread about the galaxy to other star systems via cometary and/or meteorite impact". (WK 2006l)

This approach receives some empirical support "in recent study of Martian meteorites found in Antartica and in studies of extremophile microbes. Additional support comes from a recent discovery of a bacterial ecosytem whose energy source is radioactivity". (L. Lin 2006; S. Clark 2002; WK 2006l)

In the end, unfortunately, neither approach has really succeeded in explaining the origin of life as a complex phenomenon.

3.2.2. The Evolution of Language, and Bifurcation

The second central question about biology or, more precisely, evolutionary biology (together with other related fields too) and complexity concerns the evolution of language in hominid life over time.

3.2.2.1. *The Evolution of Six Languages*

Robert Logan (2006) in *The Fifth Language* (1995), for instance, made good use of complexity theory and the idea of chaos as "information overload" to explain the emergence of different languages in human evolution—not through the classical Darwinian theory of gradual (slow) evolution, but through the more contemporary version of ruptured (rapid) evolution, or simply "punctuated evolution" to understand the "missing links" of emergent properties in the evolution of language, in conjunction with the idea of "vestiges".

The five languages in question are speech, writing, math, science, and computing—with the sixth, that is, the Internet, emerging as a fully developed language in the future. (R. Logan 2006) Each fully developed language is distinguished from others on the basis of its own distinct "semantics and syntax." (R. Logan 2006)

As Logan (2006) thus summarized the whole process, "[c]haotics and complexity theory helps us to understand two features of evolution namely vestiges and punctuated evolution or the so called 'missing links'. Each time a new level of order emerges out of chaos a discontinuity occurs explaining the missing links. A bifurcation into a new level of order retains the older level of order which explains vestigiality".

The evolution of language all started in the very early era before the emergence of Homo sapiens sapiens, when human ancestors had only "percept-based" thinking, or "percent-based proto-languages." (R. Logan 2006)

Three good examples of these proto-languages are, just to cite some main ones, (a) "manual praxic articulation (or tool making and use)", (b) "social/emotional intelligence or the language of social interaction", and (c) "pre-verbal communication which entails the use of hand signals, mime, gesture and prosodic vocalization". (R. Logan 2006)

But as "hominid life" became more complex, the percept-based proto-languages were less and less able to deal with the increasing complexity of life, so the subsequent mental chaos as "information overload" rendered the need for the evolution of a concept-based thinking ability.

3.2.2.1.1. Speech

The first stage in the evolution of language was the transition to the emergence of speech as the first human language. In other words, "[a]s our ancestors developed toolmaking, controlled fire, lived in larger social groups and engaged in large scale co-ordinated hunting their minds could no longer cope with the richness of life solely on the basis of their perceptual sensorium and as a result a new level of order emerged in the form of conceptualization and speech. Speech arose primarily as a way to control information and then was used as a tool for communication contrary to popular beliefs and inherited wisdom. Thought is not silent speech but rather speech is vocalized thought". (R. Logan 2006)

This evolution for the first human language was stretched over many millions of years: "The transition from percept based thinking to concept based thinking represented a major discontinuity in human thought. The development of the skills required for speech and conceptualization stretched over a long period of time encompassing millions of years and a number of stages in hominid evolution including Australopithecus, Homo habilis, Homo erectus, archaic Homo sapiens and ending finally with Homo sapiens sapiens or humans. Merlin Donald [1991] has identified this transition as the period of Mimetic Culture…." (R. Logan 2006)

In fact, the evolutionary "vestiges" of these proto-languages before the emergence of speech can be seen in our contemporary thought: "Transformed by spoken language and the abstract thought that followed in its wake, they also served as the prototypes of three fundamental activities of modern humans, namely technology which emerged from toolmaking, commerce which emerged from social intelligence and the fine arts which emerged from mimetic communications". (R. Logan 2006) Donald (1991: 162) thus wrote: "There is a vestigial mimetic culture embedded within our modern culture and a mimetic mind embedded within the overall architecture of the modern human mind".

3.2.2.1.2. Writing and Math

With the first emergence of speech—other languages followed later on in different bifurcations during the evolution of language.

For instance, writing and mathematics, for instance, then followed: "Mathematics and writing arose at exactly the same point in time around 3000 BC. They were part of a notational system to record commercial transactions to deal with the information overload brought about by the rapid increase in the administration and trade of agricultural commodities in the city states of Sumer. Writing and mathematics, the second and third languages after speech, immediately gave rise to the world's first formal schools to teach the new skills associated with these two languages. Schools required teachers who conducted scholarship and specialized study which in turn generated a new information overload". (R. Logan 2006)

3.2.2.1.3. Science

Then came the emergence of science a millennium later: "The fourth language, science, emerged approximately 1000 years later". (R. Logan 2006)

Although science in a more primitive form already existed in antiquity, it was the Scientific Revolution in modern times which had tremendously accelerated the advance in science, and this trend still continues today.

And science "represents an organized form of knowledge which brought a new level of order to the information overload created by writing and math". (R. Logan 2006)

3.2.2.1.4. Computing

The fifth language, computing, then emerged, as the fifth language in the evolution of language. It was added relatively more recently: "Computing, the fifth language, developed out of the need to cope with the information overload created by science just fifty years ago", especially in relation to the Information Age. (R. Logan 2006)

3.2.2.1.5. The Internet

And the sixth language is emerging rapidly before our eyes, that is, the rise of the Internet.

As Logan (2006) wrote, "Internet and the World Wide Web represent the sixth language in the evolutionary chain of verbal languages that I have already identified. The Net is transforming learning and commerce and accelerating the evolution or bifurcation of the Information Age into the Knowledge Era. The Net has its own unique semantics of Web sites, Web pages, Internets, Intranets and Extranets and it has its own unique syntax which is hypertext and hyperlinks. Every medium has its message and the message of the Internet and the World Wide Web is five fold. They are: 1. two way communication; 2. ease of access of information; 3. continuous learning; 4. alignment and integration; and 5. community. These five features are driving the emergence of the Knowledge Era which in turn is reinforcing and accelerating the use of this medium".

3.2.2.2. *Four Main Problems*

The main problems in Logan's analysis here, obviously in a way, are that it is (3.2.2.2.1) misleading, (3.2.2.2.2) exaggerating, (3.2.2.2.3) reductionistic, and (3.2.2.2.4) poor in explanation.

3.2.2.2.1. Misleading

Firstly, Logan depended on only two criteria of language, that is, syntax and semantics, to define the nature of a language. In so doing, however, he ignored other important criteria such as phonetics (and phonology, for that matter), morphology, and pragmatics (and stylistics, for that matter) that linguists use to study the nature of language. (WK 2006dd)

So, if these other criteria are included, not all the six languages in Logan's classification are really separate (distinct) languages as understood in linguistics. In this sense, his claim about the evolution of the six different (distinct) languages is therefore misleading.

But should Logan intend to use the term "language" solely as a limited form of metaphor from the field of linguistics, then his conclusion would not be less misleading, since it would become quite superficial in analysis.

3.2.2.2.2. Exaggerating

Secondly, the analysis is also exaggerating, in that, even if on the sole basis of syntax and semantics alone, it is not clear whether or not the commonalities that the languages have in common with each other are more than the differences which may distinguish and separate them, as something distinct for each.

For instance, take the case concerning "writing" and "speech". While linguists acknowledge the differences between spoken and written forms of communication in a given language, it is a far cry for those like Logan to jump to the conclusion that "writing" is therefore an independent (distinct) language which is separate from "speech".

After all, in any given language, both the spoken and written forms follow fundamentally, relatively speaking of course, the same syntactical and semantic basis of that language, albeit in different degrees and ways, up to a certain extent.

Does Logan simply exaggerate the differences among the spoken and written forms of communication (in the present example) as the ground to make them entirely different "languages" from each other altogether?

3.2.2.2.3. Reductionistic

Thirdly, the analysis is reductionistic, since it accounts for the evolution of human language and thought solely from the basis of his use of the "punctuated" evolutionary worldview, with the help of chaotics and complexity theory.

In the process, the evolution of language is reduced to this evolutionary framework, without learning from other levels in other disciplines in a way that is not somehow reducing them to this more basic level. In fact, the same critique of reductionism can be directed against Merlin Donald's work that Logan cited.

3.2.2.2.4. Poor in Explanation

Fourthly, the analysis also lacks a sufficient explanation as to why the evolution of language occurs in that punctuated way, since the needed explanation is all dressed up in the tricky appeal to complexity as an emergent process in relation to chaotics and complexity theory in the context of evolution (e.g., "vestigiality" and "bifurcation").

One can ask a deeper question, for instance, Why should the evolution or bifurcation of information overload occur in the way that it did? Are there alternative explanations from other disciplines, without the appeal to chaotics and complexity theory in punctuated evolution?

3.3. Complexity and Psychology

The same fate, however, awaits the field of psychology too, in relation to the phenomenon of complexity in action, albeit in a different way, this time, from the perspective of psychology.

Consider, for illustration, two case studies here, namely, (3.3.1) neural networks and connectionism and (3.3.2) Gödel's incompleteness theorem and artificial intelligence—in what follows, respectively.

3.3.1. Neural Networks and Connectionism

A most complex question in psychology is how exactly consciousness and intelligence emerge from decentralized neural networks (or networks of individual neurons) in the human brain?

Of course, to say that no one has succeeded in giving a widely accepted theory does not mean that we cannot talk about the problems to be resolved in the field, as a way to shed more light on the nature of complexity in action, this time, in relation to the mind. In fact, I myself already tried to propose my own new theory of consciousness in *The Future of Post-Human Consciousness* (2004).

That aside—a good illustration concerns an often cited approach useful in diverse fields like artificial intelligence, cognitive science, neuroscience, evolutionary psychology, and the philosophy of mind—that is, connectionism.

3.3.1.1. *Connectionism*

This interdisciplinary approach "models mental or behavioral phenomena as the emergent processes of interconnected networks of simple units. There are many different forms of connectionism, but the most common forms utilize neural network models". (WK 2006n)

Of course, how the units, connections, and network changes in a connectionist approach are to be formalized depends from one model to another. A good example is to use "neurons" as units in a neural network, "synapses" as connections, and "activation" as network changes over time (e.g., a numerical value for some aspect of a unit in the network, like "the probability that the neuron would generate an action potential spike"). (WK 2006n)

Many connectionist models tend to rely on two basic principles about the nature of the mind, namely, (a) that "[a]ny given mental state can be described as a (N)-dimensional vector of numeric activation values over neural units in a network" and (b) that "[m]emory is created by modifying the strength of the connections between neural units." (WK 2006n)

But here is also the starting point where the connectionists start to disagree much with each other. For instance, they disagree on (a) the interpretation of units (e.g., are units to be interpreted "as neurons or groups of neurons", or something else?), (b) the definition of activation (e.g., how far should activation be defined "in a variety of fashions"?), and (c) the nature of a learning algorithm (e.g., what are the different ways to modify "connections strengths" or "weights" in network changes over time?). (WK 2006n)

The disagreement like this among scholars in the approach is not trivial, since it has far reaching implications for the understanding of complexity in action, especially when the issue here concerns "the emergent processes of interconnected networks of simple units" over time.

Consider a simple example first, such as the nature of a deterministic (meaning= "well defined," with "no random parameters") dynamic system, in which "[t]he evolution rule of the dynamical system is a fixed rule that describes what future states follow from the current state. The rule is deterministic: for a given time interval only one future state follows from the current state". (WK 2006o & 2006p)

One interesting finding is that even in simple deterministic dynamic systems, the emergent processes can reveal unpredictable chaotic behaviors as network changes over time (e.g., due to a simple change in the initial conditions): "Simple nonlinear dynamical systems and even piecewise linear systems can exhibit a completely unpredictable behavior, which might seem to be random. (Remember that we are speaking of completely deterministic systems!). This unpredictable behavior has been called chaos". (WK 2006o)

It is fitting, thus, for W. Freeman (1992) to suggest that "chaos may be an important source of novelty in nature" (as already mentioned in Chap. 2). (D. Green 2001)

Different scholars have worked on the contributive effects of chaos on emergent behaviors, be they about the "the edge of chaos" by C. Langton (1990), or the "chaotic edge" by D. Green (1994), just to cite two instances.

The word "chaos" has a technical meaning in complexity theory, however. For instance, to be "chaotic" in a dynamical system, many scientists identify some main distinctive properties, and examples include, namely, (a) "sensitive to initial conditions" (i.e., "an arbitrarily small perturbation of the current trajectory may lead to significantly different future behavior"), (b) "topologically mixing" (e.g., "the system will evolve over time so that any given region or open set of its phase space will eventually overlap with any other given region"), and (c) "dense" in its periodic orbits (i.e., iterated or repeated functions over time in the system). (WK 2006p)

Lest any misunderstanding occurs, here "the focus is not on finding precise solutions to the equations defining the dynamical system (which is often hopeless), but rather to answer questions like 'Will the system settle down to a steady state in the long term, and if so, what are the possible attractors?' or 'Does the long-term behavior of the system depend on its initial condition?' Note that the chaotic behavior of complicated systems is not the issue. Meteorology has been known for years to involve complicated—even chaotic—behavior. Chaos theory has been so surprising because chaos can be found within almost trivial systems". (WK 2006o)

3.3.1.2. *Challenging Problems to Be Resolved*

But if chaotic behaviors emerge when interconnected networks of simple units evolve over time even in almost trivial deterministic dynamic systems, how much more so can one expect some sorts of unpredictable behaviors for more complex systems with more interconnected networks of myriad units over time?

If so, what exactly does connectionism really explain, in the end, about emergent properties? For the critics, connectionism does not explain much of anything about the emergent properties, other than pointing out some patterns over time to be further understood and explained.

Of course, this is not to say that connectionism is useless. It can teach us something. For instance, David Green (2001) and David Newth rightly commented, at this juncture, that "living neural systems are prone to respond chaotically....[W.J.] Freeman suggests that chaos may be an important source of novelty in nature" (as indicated above).

Yet, connectionism, while enjoying its popularity in the 1980's, was increasingly criticized by others like Jerry Fodor and Steven Pinker who questioned its promise: "These theorists argued that connectionism, as it was being developed at that time, was in danger of obliterating what they saw as the progress being made in the fields of cognitive science and psychology by the classical approach of computationalism". (WK 2006n)

The point here is not to side with computationism against connectionism (or vice versa)—but to simply point out the continued controversy in the debate between them.

3.3.2. Gödel's Incompleteness Theorems and Artificial Intelligence

Another debate on mental complexity concerns the implications of Gödel's incompleteness theorems for the study of artificial intelligence. (J. Teixeira 1998)

3.3.2.1. *Gödel's Incompleteness Theorems*

It all started from K. Gödel's incompleteness theorems (1931) in mathematical logic, which proved the limitations of formal systems in mathematics and thus showed that "[David] Hilbert's program to find a complete and consistent set of axioms for all of mathematics is impossible". (WK 2006cc)

For instance, Gödel's first theorem shows that "[f]or any consistent formal theory that proves basic arithmetical truths, an arithmetical statement that is true but not provable in the theory can be constructed. That is, any theory capable of expressing elementary arithmetic cannot be both consistent and complete". (WK 2006cc)

The word "theory" here "refers to an infinite set of statements, some of which are taken as true without proof (these are called axioms), and others (the theorems) that are taken as true because they are implied by the axioms". (WK 2006cc) In other words, "in...any formal system powerful enough to do a certain sort of arithmetic there will be a true sentence...that the system cannot prove". (J. Teixeira 1998) All formal systems in mathematics rely on some axioms which are not proved, so to speak.

This means that there is "a Gödel sentence (G)—that the system cannot prove....[If] the Gödel sentence is true, thus we have a capacity that the formal system lacks. G also stands for a number—

a Gödel number Gp—which results from the assignment of a code number to each sentence in the language of P that expresses metamathematical sentences. So, Gödel's incompleteness theorem is proved by finding a sentence Gp which is not provable from P". (J. Teixeira 1998)

A way out of the dilemma, whenever Gp occurs, is by way of an appeal to mathematical intuition, in that humans, unlike machines, can grasp the truth value of a proposition, even though it cannot be proved by formal reasoning (be it deductive or inductive).

But the next problem to be raised here is how exactly one can distinguish something which is mathematical intuition from something which is sheer guessing (or something comparable). This question has relentlessly haunted the debate (as will be clear shortly).

3.3.2.2. *The Lucas-Penrose Argument*

With this critique in mind—some scholars like R. Penrose (1989 & 1994) and J. Lucas (1961) then extended the argument to the field of artificial intelligence (AI) in the context of complexity theory to suggest that humans, unlike machines, have mathematical intuition, since they can understand intuitively the truthfulness of some formal proofs (even though the proofs are based on some unproved axioms) and that, consequently, "mental activity cannot be modeled as a Turing Machine", which then means that AI is not possible. (J. Teixeira 1998)

Others make a stronger argument; for instance, J. Teixeira (1998) argued that "even if mathematical intuition were mechanizable (as part of a conception of mental activity understood as the realization of an algorithm), the Turing Machine model of the human mind becomes self-refuting".

His argument is based on some essential ideas, that is, (3.3.2.2.1) undecidability, (3.3.2.2.2) Bremermann's fundamental limit, and (3.3.2.2.3) transcomputability.

Let's discuss each of the three essential ideas in what follows, in the order as cited above.

3.3.2.2.1. Undecidability

The idea of transcomputability tries to bridge complexity and undecidability to reveal that the human mind can still be different from a machine, without the appeal to mathematical intuition as traditionally understood.

To see that this is so, let us look into the issue of undecidability in relation to the works by A. Turing (1936 & 1939), whose "Halting Theorem is the computational version of Gödel's incompleteness theorem: both point to the existence of undecidable propositions within formal systems, or propositions whose truth-value is to be established by a human mind (intuitive reasoning or mathematical intuition) external to any formal system. In other words, the Halting Theorem asserts that knowing whether a specific Turing machine will halt or not is a task which cannot be mechanized, i.e., accomplished by any Turing Machine". (J. Teixeira 1998)

The explanation is simple indeed, since "any mechanical means to recognize unrecursiveness [without iteration ad infinitum] would presuppose the existence of an algorithmic solution to a given problem. In other words, we cannot know, in advance whether there is or there is not an algorithm to show that N cannot be generated by some Turing Machine". (J. Teixeira 1998)

In fact, "it has been proved that the Halting Problem is reducible to Hilbert's Tenth Problem: if they were not mutually reducible it would be possible to infer the existence of an algorithm for the Halting Problem whose undecidability has already been demonstrated by using Cantor's diagonalization". (J. Teixeira 1998)

Then, M. Davis (1976), Y. Matijasevic and J. Robinson also proved "that Hilbert's Entscheidungsproblem is unsolvable. So, if Hilbert's Tenth Problem cannot be solved, and, since Hilbert's Entscheidungsproblem—including its Turing version—and Gödel's proof go hand in hand (it can be shown that the undecidability of Hilbert's Tenth Problem is a direct consequence of Gödel's Theorem), undecidability is still a major hindrance to computability and hence a formal, a priori limitation inherent to any mechanically symbol-based artificial system". (J. Teixeira 1998)

This problem of undecidability can be further understood in the context of complexity.

To start, "Complexity Theory divides up mathematical problems into two major categories: P-problems and NP-problems, where P stands for 'polynomial time' and NP stands for 'non-deterministic-polynomial time'". (J. Teixeira 1998)

In general (especially in P-problems), "amongst all the problems of some particular size *n*, the greatest number of steps that the algorithm takes is *N*. As *n* gets larger and larger, the number of *N* is likely to get large much more rapidly than *n*. For instance, *N* might be approximately proportional to n^2 or to n^3 or to 2n. Within the category P (Polynomial) there are those problems whose increasing rates of *N* are, at most, fixed multiples of one of *n*, *n*2 *n*3 ....That is to say that for any P-problem we have *N* £ K ' *n*r". (J. Teixeira 1998)

Here, the symbols K and r are constants, so "[t]his means that *N* is no larger than some multiple of *n* raised to some fixed power".

On the other hand, there are some classes of problems which are NP-problems and thus undecidable. For examples, two good NP-problems are the Hamiltonian Circuit and the traveling salesman problem.

The challenge is this: "Given a set of towns that are to be visited by the traveling salesman one faces up the problem of calculating the simplest and shortest route he/she will take in order to avoid the necessity of passing through a town twice or even more times. If the number of towns increases to a figure greater than 100 we are likely to face combinatorial explosion and a situation in which an algorithm becomes inefficient". (J. Teixeira 1998)

As a matter of fact, "the Hamiltonian circuit and the traveling salesman belong to a special class of NP-problems called NP-complete, i.e., NP problems which can be written down and for which there is a solution as well as a checking procedure for the solution—a checking procedure which can be easily achieved in polynomial time. Nevertheless an algorithmic efficient solution for both the Hamiltonian Circuit or the Traveling Salesman Problem could not be found so far". (J. Teixeira 1998)

3.3.2.2.2. Bremermann's Fundamental Limit

Of course, one is tempted to think that the problem is technological in origin, since further improvement in computer power by way of software (e.g., the sophistication of the algorithm to be used) and hardware (e.g., the speed of the machine) would easily resolve the computational challenge in NP-problems one day.

But H. Bremermann (1977) showed some fundamental constraints on any further improvement of computation (as summarized in *Table 3.2*), to the extent that "there exists a fundamental limit for the speed and efficiency of computing machines which cannot be overcome. Such a fundamental limit stems from the idea that the maximum speed of signal traveling between the inner components of the computing machine is constrained by the speed of light, i.e., 3.108 m/second. The time-lag of signal traveling is determined by the distance between the computing machine inner devices...." (J. Teixeira 1998)

This time-lag is "in turn constrained by the so-called commutation time. Commutation time is the time-interval involved in processing information (signals) through discrete devices....Even if we supposed the (technological) possibility of building a quite small computer and minimizing/optimizing the trajectory of signal-traveling, such a fundamental limit cannot be overcome [since]...there would remain problems whose complexity can be said to be transcomputable". (J. Teixeira 1998)

But what exactly is transcomputability in the context of Bremermann's fundamental limit?

3.3.2.2.3. Transcomputability

A problem with transcomputable nature is "a NP-problem or a NP-complete problem whose algorithmic solving procedure cannot be achieved in efficient/polynomial time no matter how improved the hardware of the computing machine may be", and "it is demonstrable that Complexity Theory and that Bremermann's fundamental limit encompass parallel computation and even quantum computation...." (J. Teixeira 1998)

The reason is not hard to understand, since "the growth of temporal complexity involved in the realization of transcomputable algorithms is exponential", so "the time-length required for running some transcomputable algorithms can be as long as the age of the universe. Furthermore, it should also be noticed that the exponential temporal complexity required for the realization of transcomputable algorithms is also applicable to human brains, provided that they are also physical systems and hence subject to Bremermann's fundamental limit, at least in so far as neuronal information processing cannot occur at a speed faster than the light". (J. Teixeira 1998)

In other words, transcomputable problems, just like undecidable problems, are therefore uncomputable (comparable to the problem of intractability in computational complexity theory as introduced in Chap. 1).

3.3.2.3. *Some Problems with Mathematical Intuition*

In this sense, the idea of mathematical intuition can now be reinterpreted in a different way in the context of complexity.

In other words, "mathematical intuition can be viewed as the immediate apprehension of the result of a transcomputable algorithmic process through such a speeding up, although…[this] does not allow us to generalize such a conception to any case where the grasping of the truth-value of Gödel-like propositions obtains. The underlying assumption of such an assertion is that there are at least some mental operations which cannot be reduced or conceived as resulting from the physical activities of the brain…conceived as a Turing Machine…." (J. Teixeira 1998)

In the end, Teixeira (1998) then concluded that "Penrose fails to see the consequences of a relationship between undecidability and computational complexity. Moreover, he fails to see that functionalism becomes self-refuting whenever implementational issues come into play", especially when Bremermann's fundamental limit is put into context.

But a main problem in Teixeria's argument is that the mental operations of this mathematical intuition in terms of an "immediate apprehension of the result of a transcomputable algorithmic process through such a speeding up" are to be further analyzed and explained. Otherwise, the axioms in a formal system may not be as obvious as they may appear by way of this new version of mathematical intuition.

In the end, the danger here is that this version of mathematical intuition may well be another ghost in the machine in trying to understand the complexity of the mind.

3.4. The Enigma of Mental Complexity

The point here is to reveal how far the complex processes are yet to be fully understood in the context of biology and psychology—if only as two illustrative case studies for the phenomenon of mental complexity in action.

But there are more here on complexity than just the illustration of natural complexity (in Chap. 2) and mental complexity (here in Chap. 3).

The next step is to examine societal complexity in Chap. 4, to which we now turn.

Table 3.1. Mental Complexity

- **Complexity and Biology**
  - Ex: The evolution of life, and autocatalytic set
  - Ex: The evolution of language, and bifurcation

- **Complexity and Psychology**
  - Ex: Neural networks and connectionism
  - Ex: Gödel's incompleteness theorems and artificial intelligence

Notes: The examples in the categories are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they necessarily mutually exclusive. And some can be easily re-classified elsewhere. As generalities, they allow exceptions.

Sources: A summary of Chap. 3 of *FC*

Table 3.2. Two Fundamental Constraints on Computation (Part I)

- **The Problem of Bremermann's Fundamental Limit**
  - H. Bremermann (1977) showed some fundamental constraints on any further improvement of computation, to the extent that "there exists a fundamental limit for the speed and efficiency of computing machines which cannot be overcome. Such a fundamental limit stems from the idea that the maximum speed of signal traveling between the inner components of the computing machine is constrained by the speed of light, i.e., 3.108 m/second. The time-lag of signal traveling is determined by the distance between the computing machine inner devices...." (J. Teixeira 1998)
  - This time-lag is "in turn constrained by the so-called commutation time. Commutation time is the time-interval involved in processing information (signals) through discrete devices....Even if we supposed the (technological) possibility of building a quite small computer and minimizing/optimizing the trajectory of signal-traveling, such a fundamental limit cannot be overcome [since]...there would remain problems whose complexity can be said to be transcomputable". (J. Teixeira 1998)

- **The Problem of Intractability**
  - In "[c]omputational complexity theory...problems...can be classified by complexity class according to the time it takes for an algorithm to solve them as function of the problem size....Even though a problem may be solvable computationally in principle, but in actual practice it may not be that simple. These problems might require large amounts of time or an inordinate amount of space". (WK 2006 & 2006a)
  - So, this means that "[t]here exists a certain class of problems that although they are solvable in principle they require so much time or space that it is not practical to attempt to solve them. These problems are called Intractable". (WK 2006)

(continued on next page)

Table 3.2. Two Fundamental Constraints on Computation (Part II)

Notes: The examples in the categories are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they necessarily mutually exclusive. And some can be easily re-classified elsewhere. As generalities, they allow exceptions.

Sources: A summary of *Sec. 1.2* & *Sec. 3.3.2* of *FC*

• Part Four •

Society

• Chapter Four •

Societal Complexity

> [W]e live in a world that reflects the enormous variety and diversity of humanity in their knowledge, attitudes, and behaviors, interacting with each other in an enormous range of institutional frameworks. What emerges in the aggregate may have little to do with what happens at the individual level. But this aggregate cannot be simply described by some set of aggregate equations. It emerges out of the soup of the individual and particular with all its multiform interactions and peculiarities.
>
> —J. Barkley Rosser (2003)

4.1. The Impact of Societal Complexity

Complexity shows its face again in society, especially in relation to different domains at the sociological level.

Although there are many different domains at the sociological level, four major ones are of relevant interest here, which are, namely, (4.2) social organizations, (4.3) social institutions, (4.4) social structure, and (4.5) social stratifications—to be analyzed hereafter, in that order, and summarized in *Table 4.1*.

Consider first social organizations below, to be followed by the analysis of the other three, respectively.

4.2. Complexity and Social Organizations

Social organizations can reveal their complex behaviors in an illuminating way, which counters conventional wisdom.

Perhaps two case studies are worth considering thereafter, namely, (4.2.1) normal accidents and (4.2.2) garbage can theory, respectively.

4.2.1. Sheer Complexity and Normal Accidents

Complexity theory has been used to study "how organizations or firms adapt to their environments". (2006q) Specifically, it "treats organizations and firms as collections of strategies and structures", and, through these connected structures and mutual interactions, some emergent processes reveal interesting organizational behaviors, which are not quite exactly predictable.

A good instance of this work is the one by Charles Perrow (1984) on "system accidents", which he later called "normal accidents". (WK 2006r) It should be stressed, however, that there is a close linkage between complexity theory and catastrophe theory in this section.

With this clarification in mind—the technical term "accident" here refers to "the unanticipated interaction of multiple failures" from either an organizational origin or a technological one (or both, sometimes) in a complex system. The important point to mention here is that "[t]hese accidents are easy to see in hindsight, but very hard to see in foresight. The system just has too many possible action pathways". (WK 2006r)

The reason is that "the experienced professional operates primarily by sense of feel, with logic only supplementing this as needed. Once an enterprise passes a certain point in size, with many employees, specialization, backup systems, double-checking, detailed manuals, and complex communication, employees re-course primarily to logic and being 'right'. The result can be clumsy. Some accidents become less likely, but system accidents, somewhat more likely”. (WK 2006r)

4.2.1.1. *The Crash of ValuJet 592*

Consider this more detailed description of the crash of ValuJet 592 in May 1996 (which could have been prevented) as a case study: “Mechanics removed oxygen canisters from three older aircraft and put in new ones....[T]he old ones...were simply put into cardboard boxes and then sat on a warehouse floor for a number of weeks. And they had been mistakenly green-tagged to mean serviceable. A shipping clerk was later instructed to get the warehouse in shape for an inspection....He mistakenly took the green tags to mean non-serviceable and further concluded that the canisters were therefore empty....” (WK 2006r)

But why didn’t the clerk check the safety manual to make sure? Well, the reason is that “[t]he safety manual was neither helpful for him nor for the mechanics, talking about 'expired' canisters and 'expended' canisters. The five boxes of canisters were categorized as 'company material', and along with two large tires and a smaller nose tire, were loaded into the plane's forward cargo hold for a flight on the afternoon of Saturday, May 11, 1996. A fire broke minutes after take-off. The plane crashed. All five crew members and hundred and five passengers were killed. If the oxygen generators had been better labeled—that they generate oxygen through a chemical reaction that produces heat—the crash may have been averted”. (WK 2006r)

4.2.1.2. *A Challenging Question*

The point here is not that society would be better off without complex organizations (or technologies, for that matter), but simply that complexity has its negative double, and “this cost has typically been underestimated”. (WK 2006r)

That being said—one can still ask whether or not the pieces of the puzzle are put together into a coherent story by hindsight and therefore whether or not the story really helped to explain the crash. Or, is there something else which is missing but which can explain further why the jet crashed in the way it did?

Remember, the consistency in a story does not imply its correspondence to reality. After all, philosophers often make a distinction between the correspondence theory of truth and the consistency theory of truth as two competing versions in epistemology (or the philosophy of knowledge).

4.2.2. Organizational Anarchy and Garbage Can Model

Complexity can take its toll in a different way.

An unusual study of this comes from the join research in 1972 by Michael D. Cohen, James G. March and Johan P. Olsen to challenge the classical model of organizational theory and to replace it with a new one—namely, Garbage Can Model. (WK 2006s)

The model focuses on something which makes classical theory rather uncomfortable to deal with, in that "ambiguous behaviors" in "extreme cases of aggregate uncertainty in decision environments would trigger behavioral responses which, at least from a distance, appear 'irrational' or at least not in compliance with the total/global rationality of 'economic man'". (WK 2006s)

In other words, the Garbage Can Model "tried to expand organizational decision theory into the then uncharted field of organizational anarchy which is characterized by 'problematic preferences', 'unclear technology' and 'fluid participation'. 'The theoretical breakthrough of the Garbage Can Model is that it disconnects problems, solutions and decision makers from each other, unlike traditional decision theory. Specific decisions do not follow an orderly process from problem to solution, but are outcomes of several relatively independent stream of events within the organization'". (WK 2006s)

Let's examine more closely (4.2.2.1) the problematic assumption (in classical theory) of the orderly process from problems to solutions into four stages, which the Garbage Can Model questions—and then (4.2.2.2) the inherent problem in the Garbage Can Model itself.

4.2.2.1. *The Four Stages in Classical Theory*

The four stages are, namely, (4.2.2.1.1) the "problems" stage, (4.2.2.1.2) the "solutions" stage, (4.2.2.1.3) the "choice opportunities" stage, and (4.2.2.1.4) the "participation" stage.

We can now consider each of these stages below, in the order as listed.

4.2.2.1.1. The "Problems" Stage

Firstly, there is the "problems" stage at the start of the process: "Problems require attention, they are the result of performance gaps or the inability to predict the future. Thus, problems may originate inside or outside the organization. Traditionally, it has been assumed that problems trigger decision processes; if they are sufficiently grave, this may happen. Usually, however [that is, contrary to the classical view], organization man goes through the 'garbage' and looks for a suitable fix, called a 'solution'". (WK 2006s)

4.2.2.1.2. The "Solutions" Stage

Secondly, there is the "solutions" stage: "Solutions...have a life on their own [contrary to the classical view]. They are distinct from problems which they might be called on to solve. Solutions are answers (more or less actively) looking for a question. Participants may have ideas for solutions; they may be attracted to specific solutions and volunteer to play the advocate". (WK 2006s)

In fact, "[o]nly trivial solutions do not require advocacy and preparations. Significant solutions have to be prepared without knowledge of the problems they might have to solve". (WK 2006s)

4.2.2.1.3. The "Choice Opportunities" Stage

Thirdly, the next stage is about "choice opportunities": "Choice opportunities...are occasions when organizations are expected (or think they are expected) to produce behavior that can be called a decision (or an 'initiative'). Just like politicians cherish 'photo opportunities', organization man needs occasional 'decision opportunities' for reasons unrelated to the decision itself"—contrary to the classical view. (WK 2006s)

4.2.2.1.4. The "Participation" Stage

Fourthly, there is also the role for "participants": "Participants...come and go; participation varies between problems and solutions. Participation may vary depending on the other time demands of participants (independent from the particular 'decision' situation under study). Participants may have favorite problems or favorite solutions which they carry around with them...." (WK 2006s)

Worse, in some extreme cases, the problem of organizational anarchy can even be much more severe: "Organizations operate on the basis of inconsistent and ill-defined preferences; their own processes are not understood by their members; they operate by trial and error; their boundaries are uncertain and changing; decision-makers for any particular choice change capriciously. To understand organizational processes, one can view choice opportunities as garbage cans into which various kinds of problems and solutions are dumped. The mix of garbage depends on the mix of labeled cans available, on what garbage is currently produced and the speed with which garbage and garbage cans are removed". (WK 2006s)

The point here is that each of these four stages has a life of its own to play out, somewhat independent of each other, with some unpredictable emergent properties over time, to the extent that social organizations are more anarchic (undeterminable) than is conventionally acknowledged. The classical assumption about the orderly transition from problems to solutions is therefore more a myth than a reality.

4.2.2.2. *Some Criticisms*

Of course, this conclusion by the study is not without criticisms, although there is some truth in it.

For instance, W. Richard Scott (2002) in *Organizations: Rational, Natural, and Open Systems* proposed alternative theories of organizations for a more complete analysis, including diverse theories to choose from a more complete set, including "open" system theories of organizations (e.g., Jay Galbraith's contingency theory of organizations), "natural" system theories of organizations (e.g., Elton Mayo's theory of Hawtorne effect on diverse motives and values, and Chester Barnard's theory of cooperative system), and "rational" system theories of organizations (e.g., Henri Fayol's administrative theory, Frederick Taylor's theory of scientific management, and Herbert Simon's theory of administrative behavior).

With this more comprehensive set of theories in mind—a good question to ask the authors of the Garbage Can Model is whether or not they are reductionistic in their obsession with organizational anarchy.

4.3. Complexity and Social Institutions

In social institutions, complexity has its own share of impact. Perhaps the best way to show this societal complexity in action is by way of an analysis of the phenomenon in the economic institution.

Consider, then, two case studies, namely, (4.3.1) multiform interactions and spontaneous order and (4.3.2) random walk hypothesis and the financial markets—to be analyzed hereafter, respectively.

4.3.1. Multiform Interactions and Spontaneous Order

The study of complexity in economics has the intellectual virtue to reveal some of the questionable assumptions long held rather uncritically by conventional economists.

4.3.1.1. *Non-Linear and Discontinuous Economic Reality*

J. Barkley Rosser (2003) put it aptly, when he wrote: "Whereas it had been widely believed that economic reality could be reasonably described by sets of pairs of linear supply and demand curves intersecting in single equilibrium points to which markets easily and automatically moved, now it is understood that many markets and situations do not behave so well. Economic reality is rife with nonlinearity, discontinuity, and a variety of phenomena that are not so easily predicted or understood....These phenomena have come to be labeled as complexity in economics. Even what seems simple in economics generally arises from behavior not reflecting rational expectations....”

But why? The reason is that “we live in a world that reflects the enormous variety and diversity of humanity in their knowledge, attitudes, and behaviors, interacting with each other in an enormous range of institutional frameworks. What emerges in the aggregate may have little to do with what happens at the individual level. But this aggregate cannot be simply described by some set of aggregate equations. It emerges out of the soup of the individual and particular with all its multiform interactions and peculiarities”. (J. Rosser 2003)

How to study these “multiform interactions and peculiarities” is a major challenge to the human mind. Increasingly, the ordinary human mind can no longer process the enormous amounts of info as needed for the understanding of certain forms of complexity.

Instead, powerful computers come to the rescue, as “we see a greater emphasis on computer simulations and experimental methods to inductively determine possible outcomes and ranges of solutions. Emergent phenomena from complex systems are not usually discovered by theorems but more frequently by the use of increasingly powerful computers to explore the limits and possibilities that can arise”. (J. Rosser 2003)

4.3.1.2. *The Danger of Ideological Contamination*

Some, however, take a shortcut with a libertarian ideological bent in advocating a free market approach to economics, since order can ultimately emerge out of the seemingly chaotic “multiform interactions and peculiarities” of individual economic agents, so they dogmatically think.

Good examples of scholars in this ideological category are those in the Austrian School, like Don Lavoie (1989), who argued that “the idea of emergent order out of complexity explains the phenomenon of the spontaneous order of free market systems. Lavoie’s arguments draw heavily on earlier arguments by Friedrich Hayek (1948 & 1967) who was one of the first thinkers in any discipline to consider seriously the problem of complexity". (J. Rosser 2003)

Of course, this ideological bent should be guarded against in complexity study, as its proponents abuse it for the glorification of the free market (without government intervention).

4.3.2. Random Walk Hypothesis and the Financial Markets

An related argument which is comparable to the spontaneous order (as described in the previous sub-section) is the use of randomness to describe the behaviors of the stock markets.

4.3.2.1. *The Random Walk Hypothesis*

A well known example is the one by Burton Malkiel (1973), who proposed "the random walk hypothesis" (RWH) in financial theory to argue that "market prices evolve according to a random walk and thus cannot be predicted". (WK 2006aa)

In fact, the random walk hypothesis is in good company with the "efficient market hypothesis" (EMH) proposed in the 1960's by Eugene Fama (1965) at the University of Chicago Graduate School of Business, who argued that, since "financial markets are 'efficient', or...prices on traded assets, e.g. stocks, bonds, or property, already reflect all known information and therefore are unbiased in the sense that they reflect the collective beliefs of all investors about future prospects". (WK 2006bb)

So their conclusion is that "it is not possible to consistently outperform the market—appropriately adjusted for risk—by using any information that the market already knows, except through luck. Information or news in the EMH is defined as anything that may affect stock prices that is unknowable in the present and thus appears randomly in the future. This random information will be the cause of future stock price changes". (WK 2006bb)

In this sense, if one tries to predict the prices of stocks in the financial markets, one can do no better than simply flipping a coin, since stock prices change in a way not exactly predictable, as the market is random, emerging out of the multiform interactions among myriad investors.

4.3.2.2. *The Alternative Explanation in Behavioral Finance*

However, the main criticism against RWH (and for that matter, EMH) is that the financial markets are not entirely unpredictable.

For instance, in "behavioral finance", Andrew Lo (1999) of M.I.T. and A. Craig MacKinlay presented a counter-argument in their book titled *A Non-Random Walk Down Wall St.*, in "that the random walk does not exist and that even the casual observer can look at the many stock and index charts generated over the years and see the trends. If the market were random,...there would never be the many long rises and declines so clearly evident in charts". (WK 2006aa)

But those defending RWH rebuke by saying "that past performance cannot be indicative of future performance in a semi-strong market economy". (WK 2006aa)

Yet, the critics are not satisfied, as "[s]ome economists, mathematicians and market practitioners cannot believe that man-made markets are strong-form efficient when there are prima facie reasons for inefficiency including the slow diffusion of information, the relatively great power of some market participants (e.g. financial institutions), and the existence of apparently sophisticated professional investors". (WK 2006bb)

Other critics argue instead by way of a psychological interpretation, in that some calculative rational players in the stock markets can take advantage of "irrational" and inexperienced ones, to the extent they can still make some profits out of the latter. (WK 2006bb)

In other words, "rational (and hence, presumably, powerful) participants should always immediately take advantage of the artificially high or artificially low prices caused by the irrational participants by taking opposing positions, but this is observably not, in general, enough to prevent bubbles and crashes developing. It may be inferred that many rational participants are aware of the irrationality of the market at extremes and are willing to allow irrational participants to drive the market as far as they will, and only take advantage of the prices when they have more than merely fundamental reasons that the market will return towards fair value....Alan Greenspan warned of 'irrational exuberance' in the markets in 1996, but some traders who sold short new economy stocks that seemed to be greatly overpriced around this time had to accept serious losses as prices reached even more extraordinary levels. As John Maynard Keynes succinctly commented, 'Markets can remain irrational longer than you can remain solvent'". (WK 2006bb)

The debate still continues to our day and age about whether or not the financial markets can be predicted—and to what degree it can be so.

4.4. Complexity and Social Structure

In social structure, complexity has a conflicting nature, especially when confronted in the context of multiple conflicts among myriad groups in social stratification.

Societal complexity in the context of social structure can best be illuminated by way of an analysis of two case studies, namely, (4.4.1) social segregation in the context of macro- and micro-sociological interactions and (4.4.2) norms and social inequality in abstract games—respectively hereafter.

4.4.1. Social Segregation and the Macro-Micro Interactions

Perhaps the study of complexity by T. C. Schelling (1971) is more instructive, to show, ironically, "that high degrees of residential segregation could occur even when individuals were prepared to have a majority of people of different ethnicity living in their neighborhood". (N. Gilbert 2004)

4.4.1.1. *A Simulation of Residential Segregation*

In the study, Schelling "modeled a neighborhood in which homes were represented by squares on a grid. Each grid square was occupied by one simulated household (...either a green or a red household), or was unoccupied (black). When the simulation is run, each simulated household in turn looks at its eight neighboring grid squares to see how many neighbors are of its own color and how many of the other color. If the number of neighbors of the same color is not sufficiently high (for example, if there are fewer than three neighbors of its own color), the household 'moves' to a randomly chosen unoccupied square elsewhere on the grid. Then the next household considers its neighbors and so on, until every household comes to rest at a spot where it is content with the balance of colors of its neighbors”. (N. Gilbert 2004)

What Schelling found is highly intriguing, in that “when the simulation reaches a stopping point, where households no longer wish to move, there is always a pattern of clusters of adjacent households of the same color. He proposed that this simulation mimicked the behavior of whites fleeing from predominantly black neighborhoods, and observed from his experiments with the simulation that even when whites were content to live in locations where black neighbors were the majority, the clustering still developed”. (N. Gilbert 2004)

In other words, his conclusion was that “residential segregation” at the macro-sociological level “could occur even when households were prepared to live among those of the other color” at the micro-sociological level. (N. Gilbert 2004)

4.4.1.2. *Some Weaknesses in Social Simulation*

Now, there are weaknesses in social simulation like this, which, however, are postponed for analysis until the next section on complexity and social systems.

4.4.2. Norms and Social Inequality in Abstract Games

Another illustration of complexity in action in the context of social structure is the social simulations by R. Conte (1995), C. Castelfranchi (1998), M. Paolucci, N. Saam (1999), A. Harrer, A. Staller (2001), P. Petta, F. Flentge (2001), D. Polani, Thomas

Uthmann, D. Hales (2002), and S. Younger (2004) on social norms and social inequality over time.

4.4.2.1. *"Blind Aggression" and "Finders-Keeper"*

For instance, a model was designed as a game to be played out in such a way that the agents were "controlled by 'norms' (i.e. behavioral rules)" and sought "a regular grid for 'food', which they consume[d] to maintain their energy level or 'strength.' These authors carried out experiments to study the mean and variance of the distribution of strength under various normative arrangements". (N. Gilbert 2004)

Two good instances are "blind aggression" and "finders-keeper". (N. Gilbert 2004) In "blind aggression", "agents attack other agents to grab their food, regardless of whether the attacked agent is stronger than they are"; and in the case about "finders-keeper", "agents respect 'property rights' and do not attack other agents for their food".

Their essential point is that "under some conditions (e.g. when the agents start with more or less equal levels of strength), the finders-keeper norm reduces inequality, but if the agents start with an unequal distribution, holding to the same norm can increase the degree of inequality. These findings are not directly descriptive of or applicable to any real human society or group, although they do raise some interesting questions for the conceptualization of power and for understanding the origins of social inequality". (N. Gilbert 2004)

4.4.2.2. *Advantages and Disadvantages in Social Simulation*

However, in both case studies (that is, on social segregation in the context of macro- and micro-sociological interactions as discussed in the previous sub-section, and on norms and social inequality in abstract games here), there are advantages and disadvantages, which are to be addressed in the next section hereafter.

4.5. Complexity and Social Systems

In social systems, complexity reveals a rather intriguing face, especially with the advance of powerful supercomputers in their applications by way of computer simulation for the understanding of social reality from the vantage point of artificial society.

Two case studies are illustrative here, (4.5.1) cellular automaton and complex systems and (4.5.2) artificial society and social simulation—to be discussed in the following order.

4.5.1. Cellular Automaton and Complex Systems

A controversial attempt to use computer simulation in the field of computation for the study of complexity is by way of the use of rule 110 cellular automaton by Stephen Wolfram (2002).

4.5.1.1. *Rule 110 Cellular Automaton*

Wolfram claims that there is some underlying simplicity in all complex systems and that one way to find it is by way of computer simulation to design computational models in simple systems, since "very simple rules often generate great complexity". (WK 2006t)

Take a small example about rule 110 cellular automaton, as an illustration. Now, rule 110 cellular automaton has a one-dimensional and two-state structure (which is very simple), with "current pattern" using only 1 and 0 symbols (i.e., 111, 110, 101, 100, 011, 010, 001, 000) and "new state for center cell" (i.e., either 1 or 0 symbol). (WK 2006z)

Since Rule 110 is Turing complete (meaning="being able to perform any computational task" in many computational models, though not necessarily "efficiently, quickly, or easily"), one can use the rule within another computational model, and a good example is the universal model like the "cyclic tag system". (WK 2006t, 2006y & 2006z)

To make things simple, this can be done by way of using some "self-perpetuating localized patterns, that could be constructed on an infinitely repeating pattern in a Rule 110 universe, and second, devising a way for combinations of these structures to interact in a fashion that could be exploited for computation". (WK 2006z)

The computer simulation is programmed with certain properties and rules, and examples include (a) a "data string" (e.g., either 1 or 0 symbol), (b) "production rules" (i.e., an "infinitely repeating series" stipulating a cell how to "start on the right and move leftward) and (c) "clock pulses" (i.e., an "infinitely repeating series" stipulating a cell how to start on the left and move rightward"). (WK 2006z) In other words, "production rules" and "clock pulses" are opposite complements of each other.

What Wolfram tries to show here is that simple as this computational model is, it tends to produce some complex emergent properties over time, especially when the program is allowed to run over a long series of iterated patterns, subject to the constraints as imposed upon by the essential rules and properties.

Wolfram claims that simple programs have emergent properties which can help us understand complex phenomena like "thermodynamic behavior, continuum behavior, conserved quantities, percolation, sensitive dependence on initial conditions,...traffic, material fracture, crystal growth, biological growth, and various sociological, geological and ecological phenomena". (WK 2006t)

And he further argues that "making them [the systems] more complicated seems to have little effect on their overall complexity". Therefore, there must be some underlying simplicity governing all complex systems.

The usefulness of rule 110, in this example, is that "the simpler the system, the more likely a version of it will recur in a wide variety of more complicated contexts. Therefore...simple programs will lead to a base of reusable knowledge" for the understanding of complex systems in nature. (WK 2006t)

4.5.1.2. *Some Serious Problems*

But Wolfram's bold claims invite a lot of harsh criticisms.

Four examples below suffice for the illustration of this important point, in relation to (4.5.1.2.1) not fair to other scholars, (4.5.1.2.2) highly exaggerating, (4.5.1.2.3) not as good as PRAM, and (4.5.1.2.4) misleadingly reductionistic.

4.5.1.2.1. Not Fair to Other Scholars

Firstly, it is important to stress here, however, that "the idea of the universe as a cellular automaton" was based on the pioneered works by Edward Fredkin and Konrad Zuse—and the proof of the rule 110 cellular automaton as Turing complete was provided by Wolfram's research assistant, Matthew Cook, not Wolfram himself (who has been criticized for subtly hiding all this from the reader in his book, so as to give the wrong impression that he himself came up with the ideas, which, unfortunately, are not his). (WK 2006t & 2006y)

4.5.1.2.2. Highly Exaggerating

Secondly, Wolfram's argument (for underlying simplicity in all complex systems) is highly exaggerating, since "many scientists believe that of all possible parameters [in computational models], only some actually occur in the universe. That, for instance, of all possible variations of an equation, most will be essentially meaningless" when applied to the world outside mathematics and the science of computation. (WK 2006t)

In this sense, "[t]here has...been criticism, implicit and explicit, that the study of simple [computational] programs [in computer simulation as addressed in his book] has little connection to the physical universe, and hence is of limited value". (WK 2006t)

Precisely here there is a theoretical debate in mathematics, about the foundations of mathematics. For instance, "On what ultimate basis can mathematical statements be called true"? (WK 2007) Or do they have any correspondence to reality in the world?

There are three competing theories here, namely, (a) Platonism, (b) formalism, and (c) intuitionism or constructivism (as summarized in *Table 4.2*).

(a) In the first theory known as "Platonism", argued by thinkers like Plato and Kurt Gödel, "numbers are abstract, necessarily existing objects, independent of the human mind". (WK 2007; W. Anglin 1994) For them, "the existence of a world of mathematical objects" is "independent of humans; the truths about these objects are discovered by humans." But the crucial question here is: "how do we access this world?" (WK 2007; W. Anglin 1994)

(b) In the second theory called "formalism", on the other hand, as suggested by David Hilbert (1922), "mathematics is no more or less than mathematical language. It is simply a series of games..." (WK 2007; W. Anglin 1994)

The formalists therefore are not interested in the Platonic quest and focus instead on grounding mathematics on the basis of some axioms. For instance, they argued that "[v]irtually all mathematical theorems...can be formulated as theorems of set theory. The truth of a mathematical statement...is then nothing but the claim that the statement can be derived from the axioms of set theory using the rules of formal logic". (WK 2007; W. Anglin 1994)

But Gödel's incompleteness theorems (as already discussed in Chap. 3 on mental complexity) showed that such an enterprise of formal systems is not possible without being incomplete. Furthermore, "[f]ormalism does not explain several issues: why we should use the axioms we do and not some others, why we should employ the logical rules we do and not some others...." (WK 2007; W. Anglin 1994)

(c) And in the third theory referred to as "intuitionism" or "constructivism", as advocated by L. E. J. Brouwer and Stephen Kleene (1991), "mathematics is a creation of the human mind. Numbers, like fairy tale characters, are merely mental entities, which would not exist if there were never any human minds to think about them". (WK 2007; W. Anglin 1994; P. Mancosu 1998)

Other theories along this line of denying the objective existence of mathematical statements "tend to focus on mathematical practice, and aim to describe and analyze the actual working of mathematicians as a social group. Others try to create a cognitive science of mathematics, focusing on human cognition as the origin of the reliability of mathematics when applied to the real world. These theories would propose to find foundations only in human thought, not in any objective outside construct". (WK 2007; W. Anglin 1994)

However, even intuitionism or constructivism has not been quite popular, since "the intuitionistic school had failed to attract adherents among working mathematicians, and foundered due to the difficulties of doing mathematics under the constraint of constructivism". (WK 2007; W. Anglin 1994)

So, the controversy remains today, and the criticism of Wolfram's quest for underlying simplicity for complex systems on the basis of computation is only a latest round of this eternal debate. After all, does Wolfram's "study of simple [computational] programs...has...[any] connection to the physical universe" at all? (WK 2006t)

4.5.1.2.3. Not as Good as PRAM

Thirdly, although the use of cellular automaton in computation is a progress over an alternative exploitation of either a Turing machine or a RAM (Random-Access Machine) on the basis of the degree of parallelism (not sequentialism), it is not as good as PRAM (Parallel Random Access Machine) in terms of global (not local) communication and thus does not represent the phenomenon of complexity well. (J. Machta 2006)

The reason is not hard to explain. In the field of computation, one way to classify the fundamental models of digital computation for the study of complexity is by way of two criteria, namely, (a) sequential vs. parallel in relation to the number of processors and (b) local vs. global in relation to the constraints on communication (as summarized in *Table 4.3*).

The simplest model of computation is the Turing machine, because it has a "processor with a finite number of internal states that moves along a one-dimensional data tape of arbitrary length. An elementary step in a Turing computation consists of changing the state of the head, reading from and writing to the tape, and then moving the head one square to the left or right along the tape". (J. Machta 2006)

The problem here is, of course, that the "lack of parallelism and non-local communication [in a Turing machine] means that simulating most physical processes on a Turing machine will require a number of steps that increases more rapidly than the physical time of the process that is simulated".

With this in mind, the next step in improvement is the model of a cellular automaton, which has "many simple processing elements arranged on a lattice with communication between nearest neighbor processors. In a single step, each processor reads the state of its nearest neighbors, carries out a simple logical operation based on that information and makes a transition to a new internal state". (J. Machta 2006)

But neither Turing machines nor cellular automaton allow non-local communication, which then requires the need to create more complex models like PRAM (Parallel Random Access Machine)—which is different from RAM (Random Access Machine).

In a RAM, there is "a single processor with a simple instruction set; the processor communicates with a global random access memory. In an elementary step, the processor may read from one memory cell, carry out a simple computation based on the information in the cell and its own state and then write to one memory cell. The definition of 'time' on a RAM presumes that any memory cell can be accessed in unit time". (J. Machta 2006)

But RAM is limited in being sequential (non-parallel) in the number of processors, so PRAM is used for multiple processors in computation at the same time: "The PRAM consists of many identical processors all connected to a single global random access memory and an input-output-controller....The processors are each the same as the processor of a RAM, that is, a stripped down microprocessor. The number of processors is conventionally allowed to grow polynomially (as a power) of the problem size. The shared global memory effectively allows any two processors to communicate with one another in a couple of steps. Additional rules are needed to determine what happens when two processors attempt to read from or write to the same cell. All of the devices described earlier are computationally universal, meaning that each can simulate the other in a number of steps that differs only polynomially. The Turing machine and the PRAM are at opposite extremes among computationally universal, discrete classical devices. The Turing machine does the least in an elementary step and the PRAM the most". (J. Machta 2006)

The advantage of PRAM over cellular automaton in studying the phenomenon of complexity, for instance, is precisely the "depth" that PRAM has in analyzing information among multiple units at the global level over time with emergent properties, as Machta (2006) thus explained: "[I]t is the interaction of information embodied in logical operations that leads to novelty and, potentially, complexity. Furthermore, allowing non-local communication creates a category of simple processes that can be simulated in parallel time that scales as the logarithm of the sequential time. For example, simulating the trajectory of a particle diffusing for time t can be carried out in $O(\log t)$ steps on a PRAM but requires $O(t)$ steps on a CA....PRAM time...is the computational resource that is best correlated with the potential for generating physical complexity".

4.5.1.2.4. Misleadingly Reductionistic

Fourthly, Wolfram was charged of committing the academic sin of reductionism, since he "has...been criticized for asserting that the behavior of simple systems is somehow representative of all systems". (WK 2006t)

After all, to solely use some simple rules like the rule 110 cellular automaton in computational models for the understanding of complex systems in the world does no justice to the complexity of different levels of reality in the world (as already discussed in Chap. 1 on my methodological holism and will be analyzed again in the rest of this book).

Wolfram tried to dismiss the charge of reductionism by proposing the "concept of computational irreducibility", in "that some complex computations" in complex systems "cannot be shortcutted" in any arbitrary way. (WK 2006t)

Yet, this defense does not reduce the criticisms raised by scholars in the field over time. Michael Behe (2002), for example, used the case study of biology to remind us in "The Challenge of Inreducible Complexity" that "[w]e now know that...every living cell contains many ultrasophisticated molecular machines", not reducible to any universal simplicity. So, "Wolfram's claim that natural selection is not the fundamental cause of complexity in biology has led some to state that Wolfram does not understand the theory of evolution. A common sentiment is that NKS may explain features like the forms of organisms, but does not explain their functional complexity". (WK 2006t)

Robert Rosen (2006) once rightly wrote about the danger of reductionism by being too dependent on simulable models of simple systems to understand complex ones: "It does not say that we learn nothing about complex systems from simple models; it merely says we should widen our concept of what models are".

In fact, Rosen (2007) distinguished complex systems from simple ones, in that the former cannot be simulable on the basis of computer simulation alone: "A system is simple if all its models are simulable. A system that is not simple, and that accordingly must have a nonsimulable model, is complex".

4.5.2. Artificial Society and Social Simulation

Another application of computer simulation is the use of social simulation for understanding the nature of complex social systems.

Computers are increasingly playing a major role in constructing the reality of society to be understood. More and more social scientists now make use of the technological progress made in computer power by exploiting the advantage of computer simulation for understanding complex social processes in a way which was not possible before in the older days.

A good illustration concerns (4.5.2.1) the features of "agent-based models" and (4.5.2.2) their advantages and disadvantages for the study of complexity in the context of social systems.

4.5.2.1. *The Varieties of Agent-Based Models*

Agent-based models, as Nigel Gilbert (2004) well summarized in a recent study, have different dimensions to choose from, such as

(4.5.2.1.1) "abstract vs. descriptive", (4.5.2.1.2) "artificial vs. realistic", (4.5.2.1.3) "positive vs. normative", (4.5.2.1.4) "spatial vs. network", and (4.5.2.1.5) complicated vs. "simple".

4.5.2.1.1. Abstract vs. Descriptive

Social simulation can be either abstract or descriptive, in that "[m]odels can vary in the degree to which they attempt to incorporate the detail of particular targets". (N. Gilbert 2004)

For instance, a good instance of a detailed model is the social simulation by J. S. Dean (1999), G. J. Gumerman, M. Epstein Joshua, R. L. Axtell, A. C. Swedland, M. T. Parker, and S. McCarrol on the Long House Valley in northern Arizona near Monument Valley: "The model covers a time from about A.D. 400 to 1400 and consists of agent households that inhabit a digitized version of the Long House Valley landscape". (N. Gilbert 2004)

The model is detailed enough to include the specific "rules [by agents] for determining their agricultural practices and residential locations, as well as for reproduction and mortality. Each run of the model generates a unique history of population, agricultural output, and settlement patterns which can be compared with archaeological evidence from the Valley". (N. Gilbert 2004)

By contrast, a good example of a relatively more abstract model is the social simulations by R. Conte (1995), C. Castelfranchi (1998), M. Paolucci, N. Saam (1999), A. Harrer, A. Staller (2001), P. Petta, F. Flentge (2001), D. Polani, Thomas Uthmann, D. Hales (2002), and S. Younger (2004) on the interactions between social norms and social inequality over time (as already described in the previous section).

4.5.2.1.2. Artificial vs. Realistic

Social simulation does not have to be always artificial, as it can be realistic as well. So, there is a choice between the two.

A good example of a non-realistic (artificial) social simulation is the research by J. Doran (1997), who "investigated the implications if agents were able to see what will befall them in the future (that is, have perfect foresight)." (N. Gilbert 2004)

Others, however, depend on a more realistic inspiration from existing societies, and a good example is the social simulation by B. Eidelson (2004) and I. Lustick in their "research on the effectiveness of alternative defensive strategies against a possible smallpox attack or other major epidemic. Obviously there is neither much experience nor the possibility of experimentation to compare options, such as inoculating a whole population as a precaution versus vaccinating cases after the infection has begin to spread. Their model allows a number of possibilities to be investigated and the most important parameters for confining the epidemic to be identified". (N. Gilbert 2004)

4.5.2.1.3. Positive vs. Normative

Social simulation also does not have to be always positive, as it is at times used (or abused) with normative (ideological) motives.

For instance, S. Moss (1998), in his social simulation, "developed a model to represent the decision-making of middle managers in crises and was then able to make some tentative recommendations about the appropriate organizational structures to deal with critical incidents". (N. Gilbert 2004)

But the "majority of social agent-based simulations...are intended to be positive, that is descriptive and analytical about the social phenomena studied, aiding understanding rather than providing advice". (N. Gilbert 2004)

4.5.2.1.4. Spatial vs. Network

Social simulation at times has to choose between modeling the external geographical environment and focusing primarily on the interactions among individual social agents.

A good illustration of a spatial social simulation is the work on the recreational use of Broken Arrow Canyon in Arizona by H. Gimblett (2002), R. Itami and M. Richards, "which was developed to study policies for protecting the environment and providing a good recreational experience for visitors. Options include building new trails, limiting the number of visitors, or relocating existing trails. The model includes a detailed representation of the environment, including the physical topography of the canyon". (N. Gilbert 2004)

Other scholars, however, are less interested in modeling the physical environment. For instance, A. Pyka (2001), N. Gilbert and P. Ahrweiler worked out a social simulation on an "'innovation network' in which the nodes are high tech firms that each have a knowledge base which they use to develop artifacts to launch on a simulated market. Some artifacts are successful and the firms thrive; others fail. The firms are able to improve their innovations through research or by exchanging knowledge with other firms. The form of the emergent network and its dynamics observed from the simulation are compared with data from the biotechnology and mobile personal communication sectors and shown to be qualitatively similar". (N. Gilbert 2004)

4.5.2.1.5. Complicated vs. Simple

Yet, social simulation can be either complicated or simple.

For example, K. Troitzsch (2005) and N. Gilbert used a simple social simulation to develop a "production system architecture", in which "the agent has a set of condition-action rules. An example of such a rule could be 'IF the energy level is low, THEN move one step towards the nearest food source'. The agent matches the condition part of the rule against its present situation and carries out the corresponding action. These rules might be explicitly coded as declarative statements, as in this example, or they may be implicit in a procedural algorithm". (N. Gilbert 2004)

However, the problem here is that "it is difficult to model cognitively realistic agents using such a simple mechanism and so model-builder have sometimes adopted highly sophisticated cognitive model systems to drive their agents." (N. Gilbert 2004)

The finding by K. Carley (1998), M. Prietula and Z. Lin on a comparative analysis of complicated and simple social simulation is interesting enough, since its conclusion is that "simpler models of agents are all that is needed if the objective is to predict the behavior of the organization as a whole, but more cognitively accurate models are needed to generate the same predictive accuracy at the individual or small group level". (N. Gilbert 2004)

In the end, however, what can one possibly say about the advantages and disadvantages in this business of computer simulation?

4.5.2.2. *Advantages and Disadvantages*

With the analysis of the agent-based modeling as a case study of social simulation in action—there are both (4.5.2.2.1) advantages and (4.5.2.2.2) disadvantages to remember, as described below and summarized in *Table 4.4.*

4.5.2.2.1. Advantages

Three main examples here suffice for illustration, although it should be understood that they are not exhaustive, but only illustrative.

(a) Firstly, clarity and precision are certainly the first beneficiaries of computer simulation. The reason is that computer simulation requires the specification of the "basic assumptions very clearly in order to create a useful simulation model. Every relationship to be modeled has to be specified exactly. Every parameter has to be given a value, for otherwise it will be impossible to run the simulation". (N. Gilbert 2004)

(b) Secondly, computer simulation is testable, since any "model is potentially open to inspection by other researchers, in all its detail". (N. Gilbert 2004)

(c) Thirdly, "insights into the 'emergence' of macro level phenomena from micro level actions" is clearly one of the main goals in computer simulation. (N. Gilbert 2004)

A few examples of case studies by previous researchers in this regard are instructive. For example, a "simulation by [A.] Nowak & [B.] Latané (1994)...shows how simple rules about the way in which one individual influences another's attitudes can yield results about attitude change at the level of a society". (N. Gilbert 2004)

Another example involves the work by R. Axelrod (1995) who "demonstrates how patterns of political domination can arise from a few rules followed by simulated nation states". (N. Gilbert 2004)

4.5.2.2.2. Disadvantages

Yet, computer simulation has its own weaknesses. Some examples hereafter are deemed useful.

(a) Firstly, the "benefits of clarity and precision" in computer simulation come at high costs, since "[s]imulations of complex social processes involve the estimation of many parameters, and adequate data for making the estimates can be difficult to come by". (N. Gilbert 2004)

(b) Secondly, it is also not possible to list all the assumptions inherent in a given model. The use of *ceteris paribus* is a worst abuse here.

(c) Thirdly, intelligent beings like humans are not like rocks and can be responsive to the behaviors of others, and thus the record of predictability in computer simulation results has much to improve.

The reason is easy to understand: "Societies, in particular, human societies, are...different. They seem to have rather unpredictable features, meaning that it is perilous to make exact predictions of their future development, and their characteristics at any one time seem to be affected by their past histories". (N. Gilbert 2004)

For example, W. Arthur (1989) introduced the idea of "path dependence", to show that "the adoption of one of a pair of alternative technologies within a society can be greatly influenced by minor contingencies about who chooses which technology at an early stage in their introduction". (N. Gilbert 2004)

His point here is that "human societies, institutions and organizations are complex systems, using 'complex' in the technical sense to mean that the behavior of the system as a whole cannot be determined by partitioning it and understanding the behavior of each of the parts separately, which is the classic strategy of the reductionist physical sciences. One reason why human societies are complex is that there are many, non-linear interactions between their units, that is between people. The interactions involve the transmission of knowledge and materials that often affect the behavior of the recipients. The result is that it becomes impossible to analyze a society as a whole by studying the individuals within it, one at a time. The behavior of the society is said to 'emerge' from the actions of its units". (N. Gilbert 2004)

The same criticism can be said in regard to the previous section concerning Schelling's work, since "a feature of human societies which makes then unique is that people can recognize (and therefore respond to) the emergent features....For example, households not only often cluster in segregated neighborhoods, but these neighborhoods are named and can acquire reputations that further affect the behavior of those living there and others such as employers who may stereotype the inhabitants". (N. Gilbert 2004 & 1995)

(d) Fourthly, social agents are not static, but dynamic, in that "[t]he individuals within a society are constantly 'in motion': talking, listening, doing. Society emerges from this constant change. Like a waterfall that exists only so long as the water of which it is formed is moving, a society only exists while its members are living, acting and reacting. Moreover, the units from which societies are formed, that is, people, vary greatly in their capabilities, desires, needs and knowledge, in contrast to most physical systems that are composed of similar or identical units. For these reasons, while theories of complexity developed for the understanding of natural systems can be illuminating, caution needs to be exercised in applying them directly to social phenomena". (N. Gilbert 2004)

(e) Fifthly, computer simulation may look nice and impressive, but it tends to have little relevance to the world outside mathematics and the science of computation (as already discussed in the sub-section above on the critique of Wolfram's work).

Nigel Goldenfeld (1999) and Leo P. Kadanoff rightly criticized the overdependence on the use of mathematics (be it with raw data or with colorful graphs) to simplify the world: "The ideas which form the foundation of our world-view are also very simple indeed: the world is lawful and the same basic laws hold everywhere. Everything is simple, neat, and expressible in terms of everyday mathematics, either partial differential equations, or ordinary differential equations. Everything is simple and neat—except, of course, the world".

(f) Sixthly, computer simulation has yet to resolve Bremermann's fundamental limit (as already discussed in *Sec. 3.3.2*).

(g) Seventhly, computer simulation also is not immune from the essential problem of intractability in computational complexity theory (as already introduced in *Sec. 1.2* and also in *Sec. 3.3.2*).

(h) And finally, or eighthly, there is a danger of reductionism in computer simulation for artificial society, which, after all, is not real society (as also already accounted for in the previous section on the critique of Wolfram's book).

4.6. The Uncertainty of Societal Complexity

Of course, this is not to mean that the impact of societal complexity should be dismissed. The point here is that there are both the use and abuse of complexity theory for the understanding of complex events in society.

The same can be said in regard to natural complexity (as in Chap. 2) and mental complexity (as in Chap. 3).

But this discussion is not complete without the analysis of the last type of complexity in action, that is, cultural complexity, to which we now turn in the next chapter, Chap. 5.

Table 4.1. Societal Complexity

- **Complexity and Social Organizations**
  - Ex: Sheer complexity and normal accidents
  - Ex: Organizational anarchy and Garbage Can Model

- **Complexity and Social Institutions**
  - Ex: Multiform interactions and spontaneous order
  - Ex: Random walk and the financial markets

- **Complexity and Social Structure**
  - Ex: Social segregation and the macro-micro interactions
  - Ex: Norms and social inequality in abstract games

- **Complexity and Social Systems**
  - Ex: Cellular automaton and complex systems
  - Ex: Artificial society and social simulation

Notes: The examples in the categories are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they necessarily mutually exclusive. And some can be easily re-classified elsewhere. As generalities, they allow exceptions.
Sources: A summary of Chap. 4 of *FC*

Table 4.2. The Theoretical Debate on the Foundations of Mathematics (Part I)

- **Platonism**
  - In Platonism, argued by thinkers like Plato and Kurt Gödel, "numbers are abstract, necessarily existing objects, independent of the human mind". (WK 2007; W. Anglin 1994) For them, "the existence of a world of mathematical objects" is "independent of humans; the truths about these objects are discovered by humans".
  - But the crucial question here is: "how do we access this world?" (WK 2007; W. Anglin 1994)

- **Formalism**
  - In formalism, on the other hand, as suggested by David Hilbert (1922), "mathematics is no more or less than mathematical language. It is simply a series of games..." (WK 2007; W. Anglin 1994) The formalists therefore are not interested in the Platonic quest and focus instead on grounding mathematics on the basis of some axioms. For instance, they argued that "[v]irtually all mathematical theorems...can be formulated as theorems of set theory. The truth of a mathematical statement...is then nothing but the claim that the statement can be derived from the axioms of set theory using the rules of formal logic". (WK 2007; W. Anglin 1994)
  - But Gödel's incompleteness theorems (as already discussed in Chapter Three on mental complexity) showed that such an enterprise of formal systems is not possible without being incomplete. Furthermore, "[f]ormalism does not explain several issues: why we should use the axioms we do and not some others, why we should employ the logical rules we do and not some others...." (WK 2007; W. Anglin 1994)

(continued on next page)

Table 4.2. The Theoretical Debate on the Foundations of Mathematics (Part II)

- **Intuitionism (or Constructivism)**
  - In intuitionism or constructivism, as advocated by L. E. J. Brouwer and Stephen Kleene (1991), "mathematics is a creation of the human mind. Numbers, like fairy tale characters, are merely mental entities, which would not exist if there were never any human minds to think about them". (WK 2007; W. Anglin 1994; P. Mancosu 1998)
  - Other theories along this line of denying the objective existence of mathematical statements "tend to focus on mathematical practice, and aim to describe and analyze the actual working of mathematicians as a social group. Others try to create a cognitive science of mathematics, focusing on human cognition as the origin of the reliability of mathematics when applied to the real world. These theories would propose to find foundations only in human thought, not in any objective outside construct". (WK 2007; W. Anglin 1994)
  - However, even intuitionism or constructivism has not been quite popular, since "the intuitionistic school had failed to attract adherents among working mathematicians, and foundered due to the difficulties of doing mathematics under the constraint of constructivism". (WK 2007; W. Anglin 1994)

Notes: The examples in the categories are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they necessarily mutually exclusive. And some can be easily re-classified elsewhere. As generalities, they allow exceptions.

Source: From *Sec. 4.5.1* of *FC*

Table 4.3. Four Fundamental Models of Computation

	Constraints on Communication • *Local*	• *Global*
Number of Processors		
• *Parallel*	Cellular Automaton	Parallel Random Access Machine (PRAM)
• *Sequential*	Turing Machine	Random Access Machine (RAM)

Source: A reconstruction based on the data from J. Machta (2006)

Table 4.4. Advantages and Disadvantages of Computer Simulation

- **Advantages**
  - Ex: Clarity
  - Ex: Precision
  - Ex: Empirical testability by other researchers
  - Ex: Insights into the emergence of macro level phenomena

- **Disadvantages**
  - Ex: Difficulty to gather adequate data for complex phenomena
  - Ex: Inability to list all the assumptions in a model
  - Ex: Difficulty to account for dynamic human behaviors
  - Ex: Difficulty to predict adaptive human behaviors
  - Ex: Tendency to commit reductionism
  - Ex: Overdependence on mathematics to simplify the world
  - Ex: Inability to resolve Bremermann's fundamental limit
  - Ex: Facing the essential problem of intractability

Notes: The examples in the categories are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they necessarily mutually exclusive. And some can be easily re-classified elsewhere. As generalities, they allow exceptions.
Sources: A summary of *Sec. 1.2*, *Sec. 3.3.2*, & *Sec. 4.5.2* of *FC*

This page intentionally left blank

• Part Five •

Culture

• CHAPTER FIVE •

Cultural Complexity

> An emergent concept (EC) is a slight variation on consensus reality that is accepted as plausible. The hallmarks of an emergent concept, as opposed to other memes (urban myths, or viruses of the mind) are that EC are increasingly accepted as truth or possibility, based upon other empirical or anecdotal evidence in the mind of the believer or society (in its subsets) as a whole. EC can be viewed as fad, or common causal reality building. EC have no relationship to truth or fact, but are simply engines bringing individual concepts of truth into the mainstream.
>
> —"Emergence", *Wikipedia* (2006g)

5.1. The Appeal of Cultural Complexity

The last complexity in action concerns the cultural realm, where different scholars have argued over the ages on complexity in human culture.

There are four sub-levels of cultural complexity to be examined here, namely, (5.2) complexity and religion, (5.3) complexity and morality, (5.4) complexity and epistemology, (5.5) complexity and aesthetics—to be illustrated hereafter, in that order (and summarized in *Table 5.1*).

Of course, there can be more than four sub-levels of cultural complexity to be analyzed, but the four as analyzed hereafter are deemed sufficient for the purpose of illustration.

5.2. Complexity and Religion

The first sub-level of cultural complexity concerns religion, in the context of complexity. Religion has played such a fundamental role in culture that its impact cannot be ignored when trying to understanding cultural complexity.

In the process of reviewing the literature on complexity and culture (or religion, in this specific case), it can be shown how complexity theory has been used (or abused) by both sides for and against religion.

With this caveat in mind—the two case studies hereafter concerns, namely, (5.2.1) specified complexity and divine design, as an argument for creationism and (5.2.2) self-organization and evolution, as an argument against creationism.

In either case, it is argued in the context of complexity theory.

5.2.1. Specified Complexity and Divine Design

A good instance concerns the recurrence of "the argument from design" to ever prove the existence of a supernatural being in designing the complexity of the world. And a recent work for illustration here is none other than the idea of "specified complexity" by William Dembski (2002).

Dembski (2002) first started with a simple observation: "In ordinary life, explanations that invoke chance, necessity, or design cover every eventuality. Nevertheless, in the natural sciences one of these modes of explanation is considered superfluous—namely, design. From the perspective of the natural sciences, design, as the action of an intelligent agent, is not a fundamental creative force in nature. Rather, blind natural causes, characterized by chance and necessity and ruled by unbroken laws, are thought sufficient to do all nature's creating. Darwin's theory is a case in point".

So, a sensible question to ask is therefore, “But how do we know that nature requires no help from a designing intelligence [for its emergence as a complex phenomenon]?” (W. Dembski 2002)

5.2.1.1. *The Case of “Contact”*

Dembski (2002) then took an example in order to make an argument: “For instance, how do the radio astronomers in *Contact* (the Jodie Foster movie based on Carl Sagan's novel of the same name) infer the presence of extraterrestrial intelligence in the beeps and pauses they monitor from space?”

His answer is not hard to understand: “The researchers run signals through computers that are programmed to recognize many preset patterns. Signals that do not match any of the patterns pass through the 'sieve' and are classified as random. After years of receiving apparently meaningless 'random' signals, the researchers discover a pattern of beats and pauses that corresponds to the sequence of all the prime numbers between 2 and 101. (Prime numbers, of course, are those that are divisible only by themselves and by one.) When a sequence begins with 2 beats, then a pause, 3 beats, then a pause . . . and continues all the way to 101 beats, the researchers must infer the presence of an extraterrestrial intelligence”. (W. Dembski 2002)

Why so? Dembski’s answer is that the sequence cannot be random, since it inhibits patterns along the line of “specified complexity”, which then suggests a divine design.

Listen to Dembski’s explanation: “Here's why. There's nothing in the laws of physics that requires radio signals to take one form or another. The sequence is therefore contingent rather than necessary. Also, it is a long sequence and therefore complex. Note that if the sequence lacked complexity, it could easily have happened by chance. Finally, it was not just complex but also exhibited an independently given pattern or specification (it was not just any old sequence of numbers but a mathematically significant one—the prime numbers). Intelligence leaves behind a characteristic trademark or signature—what I call 'specified complexity.' The important thing about specifications is that they be objectively given and not just imposed on events after the fact". (W. Dembski 2002)

So, this means that "[u]ndirected natural processes are incapable of generating the specified complexity in organisms....The main criticism...[here] concerns whether the Darwinian mechanism of natural selection and random variation is not in fact fully capable of generating specified complexity. More recently, in *No Free Lunch*, I show that undirected natural processes like the Darwinian mechanism are incapable of generating the specified complexity that exists in biological organisms. It follows that chance and necessity are insufficient for the natural sciences and that the natural sciences need to leave room for design". (W. Dembski 2002)

5.2.1.2. *The Flawed Logic of the Process by Elimination*

But the critics are not convinced by Dembski's claim.

A good illustration is the critique by Robert Pennock (2002), who, in "Mystery Science Theater: The Case of the Secret Agent", rebuked Dembski with this reply: "Dembski claims to detect 'specified complexity' in living things and argues that it is proof that species have been designed by an intelligent agent. One flaw in his argument is that he wants to define intelligent design negatively, as anything that is not chance or necessity. But the definition is rigged: necessity, chance, and design are not mutually exclusive categories, nor do they exhaust the possibilities. Thus, one cannot detect an intelligent agent by the process of elimination he suggests. Science requires positive evidence. This is so even when attempting to detect the imprint of human intelligence, but it is especially true when assessing the extraordinary claim that biological complexity is intentionally designed".

In the end, the problem in Dembski's claim for Pennock (2002) is that "science requires a specific model that can be tested. What exactly did the designer do, and when did he do it? Dembski's nebulous hypothesis of design, even if restricted to natural processes, provides precious little that is testable, and once supernatural processes are wedged in, it loses any chance of testability. Newton found himself stymied by the complex orbits of the planets. He could not think of a natural way to fully account for their order and concluded that God must nudge the planets into place to make the system work. (So perhaps in this one sense, Dembski is the Newton of information theory.) The origin of species once seemed equally mysterious, but Darwin followed the clues given in nature to solve that mystery. One may, of course, retain religious faith in a designer who transcends natural processes, but there is no way to dust for his fingerprints".

My point here is to not side with either Dembski's position or Pennock's rebuttal, but to provide a dialogue on complexity and religion.

5.2.2. Self-Organization and Evolution

Interestingly, unlike specified complexity above in favor of creationism—complexity theory has also used by some to argue against creationism. This is a classic example of how a theory is used and abused by both sides in their debate.

Fedor Steeman (2006), for instance, collected some good arguments which have been used over time against creationism. And one of them is most relevant here, in that "the latest findings on the field of self-organisation and chaos/complexity theory...indicate that life really is able to originate and develop on its own", without the need of divine design.

5.2.2.1. *Emergent Order*

Take the case of chaos theory as a start and revise it with complexity theory.

In accordance to chaos theory, "[t]he common principle is that from apparent disorder complex patterns and systems can emerge out of their own ('emergent properties'). Simple examples of these are complex organized natural phenomena like snow crystals, clouds, dune rows, etc, but also the structuring of the entire universe into solar-systems, galaxies, and so on. Also many computer-simulations, the so-called 'Artifical Life', indicate that there is ample reason to assume, that under the right conditions all kinds of things can organize themselves in [more] complex forms without demonstrable external influences giving direction". (F. Steeman 2006)

When used in the context of religion, Steeman tried to show that creationism is therefore not needed here in self-organization (as part of complexity theory), if evolution can work things out nicely by way of emergent properties, without a divine design at all.

5.2.2.2. *Entropy and the Second Law of Thermodynamics*

One often cited counter-argument by creationists is that the evolutionary argument indeed fails, since the increasing order in evolution is refuted by the second law of thermodynamics which suggests the increase of entropy (disorder) over time.

Three classic rebuttals of the counter-argument are available.

(a) Firstly, the second law applies only to closed systems, but evolution on earth is not a closed system, since "the earth's biosphere is an open system, because it receives energy from the sun (and from the earth's interior)". (F. Steeman 2006)

In fact, "[t]the idea of self-organization challenges an earlier paradigm of ever-decreasing order which was based on a philosophical generalization from the second law of thermodynamics in statistical thermodynamics where entropy is envisioned as a measure of the statistical 'disorder' at a microstate level. However, at the microscopic or local level, the two need not be in contradiction: it is possible for a system to reduce its entropy by transferring it to its environment....It would appear that, since isolated systems cannot decrease their entropy, only open systems can exhibit self-organization. However, such a system can gain macroscopic order while increasing its overall entropy. Specifically, a few of the system's macroscopic degrees of freedom can become more ordered at the expense of microscopic disorder". (WK 2006c)

Thus, there is a "widespread misunderstanding...of evolution", which is "the idea that evolution violates the second law of thermodynamics, which applies to isolated systems, not self-organizing organisms...." (WK 2006gg; M. Isaak 1997)

(b) Secondly, "organisms are also open systems, which entirely reconstruct the genome every time a cell divides. The 2nd law would only be applicable to individual DNA-molecules which, of course, in time would degenerate. However, as organisms channel their energy, using it to create a new DNA-molecule every time, this process is 'outmaneuvered', rendering in effect the very essence of life: combating entropy. Mutations are only copying-errors, giving occasionally beneficial variation. This has nothing to do with degeneration due to increasing entropy". (F. Steeman 2006)

In a different way, Frank Steiger (1997) argued how a system can reverse its entropy over time, if it interacts with the outside environment in such a way that the external entropy increase can more than compensate for the internal entropy decrease: "In the case of the formation of the complex molecules characteristic of living organisms, creationists raise the point that when living things decay after death, the process of decay takes place with an increase in entropy. They also point out, correctly, that a spontaneous change in a system takes place with a high degree of probability. They fail to realize, however, that probability is relative, and a spontaneous change in a system can be reversed, providing the system interacts with its surroundings in such a manner that the entropy increase in the surroundings is more than enough to reverse the system's original entropy increase".

(c) And thirdly, the creationists commit a contradiction in their argument, since it is inconsistent for them to argue against evolution by appealing to the second law of thermodynamics against the emergent complex order (which violates the increase of entropy over time in accordance to the second law) and yet, at the same time, to argue the existence of divine design for emergent complex order (which, however, is ruled out by the second law that they appeal to in the first place).

As Frank Steiger (1997) concisely described the contradiction: "They base this argument on their belief that changes in living things have a very low probability and could not occur without 'intelligent design' which overcomes the laws of thermodynamics. This represents a fundamental contradiction in which (they say) evolution is inconsistent with thermodynamics because thermodynamics doesn't permit order to spontaneously arise from disorder, but creationism (in the guise of intelligent design) doesn't have to be consistent with the laws of thermodynamics".

5.2.2.3. *A Critical Evaluation*

Those against creationism are a bit too quick in their arguments here, for good reasons.

(a) Firstly, the creation/evolution controversy is by no means settled, and the latest round on evolution and entropy is far from over yet.

A good instance is the book by Daniel Brooks (1986) and E.O. Wiley, that is, *Evolution as Entropy: Toward a Unified Theory of Biology*, which precisely tried to bridge the gap between the second law of thermodynamics and evolutionary theory, by arguing that evolution is not in contradiction with entropy.

Using a neo-Darwinian framework without the classical interpretation of natural selection as an endogenous variable, Daniel R. Brooks and E. O. Wiley tried to propose a theory of evolution based on non-equilibrium thermodynamics and information theory, such that evolution can lead to both the increase of entropy and information content (complexity) of species at the same time, or more precisely, "of a system of imperfectly reproducing organisms". (J. Collier 1986)

It becomes harder, thus, for either camp in the debate to use it for or against creationism.

(b) And secondly, as is common in all complexity studies, the "emergent properties" are yet to be explained, since "calling a phenomenon emergent is sometimes used in lieu of a more meaningful explanation". (WK 2006g)

Quite often, these words are used in such a way that those who are sympathetic to the application of complexity theory to other fields automatically offer some legitimacy to what is argued in question, without really trying to understand the missing underlying mechanisms (somehow mysteriously responsible for the emergence) or even acknowledging the sheer magnitude of the complicated interactions among so many different units—which may well be beyond the power of imagination and understanding of the human mind.

In this way, one can now understand why it is quite pertinent for me to put these two sections next to each other here, only in order to show more clearly how complexity theory has really been abused by either side in the debate for its own ulterior non-scholarly purposes.

5.3. Complexity and Morality

A related issue in religion concerns morality, although not all moral inquiries have to be reduced to religion. With this caveat in mind—and consequently, cultural complexity can be understood from the perspective of morality too (not reducible to religion).

Two case studies are of interest here, (5.3.1) free will and incomplete information and (5.3.2) moral reciprocity, and the emergent order of the world.

Let's consider each of the two case studies below, in that order.

5.3.1. Free Will and Incomplete Information

An excellent illustration here is of course the eternal debate between determinism and indeterminism in the context of free will in ethics.

At the outset, however, it should be stressed that the debate between determinism and indeterminism, say, in metaphysics and epistemology, for instance, does not necessarily involve the issue of free will.

But one practical consequence of the debate, in the context of ethics, for instance, renders the discussion of free will relevant.

5.3.1.1. *A Cross-Cultural Comparison*

As a cross-cultural comparison, let's start with Eastern cultures, where the idea of free will does not have the same meaning as the one in Western cultures.

In India and China, for instance, Buddhism treats the notion of the individual self as an illusion, since while all things can be traced back to the primordial Oneness, "every phenomenon is conditioned by, and depends on, the phenomena that it is not....In Buddhism, this teaching is used to demonstrate that to ascribe special value to any one thing is to ignore the interdependence of all things. Volitions of all sentient creatures determine the seeming reality in which we perceive ourselves as living, rather than a mechanical universe determining the volitions which humans imagine themselves to be forming". (WK 2006u)

Complex events, then, can be understood on the basis of these interdependent interactions of all things under heaven and earth.

In Western cultures, on the other hand, the idea of determinism is less dualistically understood (when compared with the Eastern version), such that there can be a clear separation between determinism and free will, to the extent that, should determinism be true, then free will would be an illusion—according to some scholars. (WK 2006u)

5.3.1.2. *Compatibilism and Incompatiblism*

Even then, however, the debate also hinges on the interpretation of the terms "determinism" and "free will".

For example, in one interpretation known as "compatibilism", free will and determinism are not mutually exclusive, since free will would still be meaningful, insofar as a person "feels" that he acts as an "independent agent" on the basis of his desires and beliefs, no matter whether or not there exists the "metaphysical truth of independent agency". (WK 2006u) Thomas Hobbes liked to advocate this position, and David Hume (1967) once wrote that "this hypothetical liberty is universally allowed to belong to every one who is not a prisoner and in chains". (WK 2006v)

On the other hand, a different interpretation known as "incompatibilism" has a stricter meaning of determinism and free will, to the extent that, should there be no metaphysical truth of independent agency, free will would not exist, even if a person "feels" that he has free will in acting in the way that he does. (WK 2006u) Baron d'Holbach, for instance, rejected free will but accepted determinism in his branch of incompatibilism, whereas Thomas Reid, Peter van Inwagen, and Robert Kane accepted free will but rejected determinism in their version of incompatibilism. (WK 2006v)

5.3.1.3. *Free Will and Ignorance in Complexity Theory*

Recently, in complexity theory, especially in relation to the "philosophy of cognitive sciences and evolutionary psychology, free will is assumed not to exist. However, an illusion of free will is created, within this theoretical context, due to the generation of infinite or computationally complex behavior from the interaction of a finite set of rules and parameters. Thus, the unpredictability of the emerging behavior from deterministic processes leads to a perception of free will, even though free will as an ontological entity is assumed not to exist". (WK 2006v)

For instance, "some strategy board games have rigorous rules in which no information (such as cards' face values) is hidden from either player and no random events (such as dice-rolling) occur in the game. Nevertheless, strategy games like chess and especially Go, with its simple deterministic rules, can have an extremely large number of unpredictable moves....Cellular automata and the generative sciences model emergent processes of social behavior on this philosophy, showing the experience of free will to be a gift of ignorance or a product of incomplete information". (WK 2006v)

5.3.1.4. *Cultural Contingency*

Consequently, cultural and sub-cultural interpretations and understandings of the debate are crucial to which position(s) a person is likely to accept in regard to determinism and free will—or, in a broader sense, cultural complexity in action.

And these interpretations and understandings can be multiple, like the ones as introduced above (e.g., the Buddhist idea of the illusion of the individual self and the importance of interdependence, the compatibilist appeal to the desires and beliefs of an individual regardless of the "metaphysical truth of independent agency", the incompatibilist emphasis on the "metaphysical truth of independent agency", and the more recent view of free will as "a gift of ignorance or a product of incomplete information" in complexity).

5.3.2. Moral Reciprocity, and the Emergent World Order

Another way to illustrate morality from the contributive perspective of complexity theory is an interesting thesis on morality as an emergent behavior.

Ulises Mejias (2005) argued, for instance, that morality is indeed an emergent behavior. Why so, indeed?

Mejias started the analysis with a critique of "cognitive structuralism", which elevates the role of reasoning as vital for the development of morality. Jean Piaget, as one figure in this group, "mapped his stages of mental growth to heteronomous and autonomous stages in the development of moral reasoning. [Lawrence] Kohlberg, following on Piaget's footsteps, outlined six stages of moral reasoning from early childhood to adult life (heteronomous morality; individualistic/instrumental morality; impersonally normative morality; social system morality; human rights/social welfare morality; and morality of universalizable, reversible, and prescriptive general principles). The idea in both cases is that as people's mental abilities develop, they are able to implement more complex and less self-centered models of morality". (U. Mejias 2005)

But this role of reasoning, for Mejias (2005), has been much exaggerated, since, as Hubert Dreyfus (1990) himself once put it, someone who acts "instinctively and appropriately to each ethical situation" does not need the use of high-powered intellectualism.

In so doing, Mejias made two essential claims, namely, (5.3.2.1) "that Reason (as defined from a Western, Humanist perspective) actually impedes moral development" and (5.3.2.2) that "morality is actually an emergent behavior—in other words, a behavior exhibited by organisms acting according to very simple rules requiring little reasoning, but behavior that results in a complex system, a system which is, in fact, the basis for the order of the Universe", especially in accordance to the idea of "moral reciprocity".

Let us examine the two claims in (5.3.2.1) and (5.3.2.2) more closely hereafter.

5.3.2.1. *The Western Humanist Perspective*

It all started with René Descartes: "The problem is that Descartes convinced himself that all we have access to in the world is our own private experience. Descartes, following on the footsteps of the Skeptics but armed with the new language of modern science, questioned the reality of perception". (U. Mejias 2005)

Later, this "Skeptical view was eventually contested (after three centuries!) by various schools, including the Pragmatics and the Existential Phenomenologists, who argued that there was no point in even asking how we perceive the 'external' world because we are embedded right into it, inseparable from it. As Heidegger argued, there is no such thing as a subject who is not being-in-the-world. 'Taking the skeptic seriously and attempting to prove that there is an external world presupposes a separation of the mind from the world of things and other people that defies a phenomenological description of how human beings make sense of everyday things and of themselves'". (U. Mejias 2005; H. Dreyfus 2000)

In this way, for Mejias (2005), "the particular anti-social way in which Reasoning was defined by Descartes...[was] adopted by Western Humanism. Under this rubric, logic (including moral logic) has been defined in the West as something the individual does in isolation, not as part of a system".

Norbert Elias (1998) thus criticized the Cartesian thought: "Descartes' Cogito ['I think therefore I am'], with its accent on the

I, was also a sign of this change in the position of the individual person in his society...The isolated thinker perceived himself—or more precisely, his own thought, his 'reason'—as the only real, indubitable thing. All else might possibly be an illusion conjured up by the Devil, but not this, not his own existence as thinker. This form of I-identity, the perception of one's own person as a we-less I, has spread wide and deep since then". (U. Mejias 2005)

5.3.2.2. *Moral Reciprocity*

By rejecting the school of "cognitive structuralism," Mejias (2005) argued for the idea of "moral reciprocity" to counter the isolated Cartesian individualist monad, in the context of the larger emergent order of the world, as an emergent property.

Unlike the Cartesian isolated framework, moral reciprocity "has more to do with the way the Universe works than with the particular characteristics of 'pure reason'. The fact that moral reciprocity does not require pure reason has been exemplified, among other instances, by the Prisoners' Dilemma competitions. In this tournament, simple software routines that learn to cooperate with each other do better than those that focus on competing with each other (for a recount of these tournaments, see for example Grossman...[2004]). This kind of behavior is referred to as emergence....My thesis is that the Universe would work much better without this brand of 'logic' and that Individualistic Reasoning is in fact a deviation from the type of logic that actually promotes moral behavior". (U. Mejias 2005)

The key mechanism here is from complexity theory that Mejias appealed to, with the work of Steven Johnson in mind: "Emergence is what happens when the whole is smarter than the sum of its parts. It's what happens when you have a system of relatively simple-minded component parts—often there are thousands or millions of them—and they interact in relatively simple ways. And yet somehow out of all this interaction some higher level structure or intelligence appears, usually without any master planner calling the shots. These kinds of systems tend to evolve from the ground up". (U. Mejias 2005)

As Mejias (2005) quoted Johnson, “[emergent systems]...solve problems by drawing on masses of relatively stupid elements, rather than a single, intelligent 'executive branch'. They are bottom up systems, not top-down. They get their smarts from below... In these systems, agents residing on one scale start producing behavior that lies one scale above them: ants create colonies; urbanites create neighborhoods; simple pattern-recognition software learns how to recommend new books. The movement from low-level rules to higher-level sophistication is what we call emergence....Emergent behaviors...are all about living within the boundaries defined by rules, but also using that space to create something greater than the sum of its parts”.

Mejias (2005) then utilized the idea of simple rule in complex systems to propose moral reciprocity: “How does morality fit into this model? Well, the simple rule is moral reciprocity. The 'stupid' agents are all living things (regardless of their level of reasoning). The complex emergent behavior, the sum greater than the parts, is Universal Order. One of the things that makes emergent systems durable and easy to propagate is that they are adaptive. Moral reciprocity is universal because there is no 'executive branch' that needs to tell everything in the Universe how to behave; rather, the 'DNA' of the behavior is widely spread, and organisms—from simple jellyfish to complex humans—can adapt the rules and work out contextually what the logical/morally-right thing to do is”.

His point here is not that morality is easy to apply or that humans are as simple as organisms like jellyfish, but that, “as Dreyfus (1990) argues, the idea that therefore an intellectual approach to moral reasoning is bound to be superior than an intuitive approach might have more to do with our Cartesian biases than with the way things actually work. Dreyfus puts forth a model of moral development that resembles more the process of gaining mastery in driving a vehicle or playing chess than the process of philosophizing: expertise does not constitute deep pondering and analyzing of each move, but comes intuitively”. (U. Mejias 2005)

It is quite obvious that Mejias (2005) disliked what he called “the rational elite” in much of Western individualist ethics, as he wrote: "In short, when individuals apply Individualistic Reasoning to define morals (in an attempt to become the 'executive branch' of morality), they stop being part of the emergent system, of the universal order. Individualistic Reasoning presupposes that morality is a function of the rational elite, those organisms with advanced reasoning skills (who for some strange reason are mostly white adult males). Emergent moral reasoning, on the other hand, presupposes that moral reciprocity is a function of the Universe. Everything and everyone acts morally in the sense that their interactions are part of the logic of the Universe, the logic of moral reciprocity. Moral reciprocity just makes logical sense, like 2+2=4; it just happens. It is encoded into everything in the Universe".

But if moral reciprocity is in accordance to the emergent order of the world, why is there evil? Here is Mejias's answer: "The answer to this question is that immorality, in the form of moral irreciprocity, is also part of the emergent system. In fact, it actually serves a very important pedagogical function. It ensures that moral reciprocity spreads virally, in the sense that by suffering or observing moral irreciprocity, everything in the Universe learns—using the most basic reasoning skills, if not mere instincts—that moral reciprocity is the only strategy that guarantees survival. Even the Prisoners' Dilemma software can figure that out quickly. If we didn't have deviations (in the form of moral irreciprocity), we would not be aware that moral reciprocity makes logical sense. The exception proves the rule".

5.3.2.3. *A Rebuttal*

Yet, the argument for moral reciprocity in relation to morality as an emergent behavior vis-à-vis the world order is, albeit highly interesting, quite problematic in four major ways.

(a) Firstly, it assumes too much an emergent order out of the interactions among myriad individuals following simple rules. Why should order necessarily be the outcome? How about chaos? Or some other outcomes?

This reminds us, in a painful way, that the Libertarians (as argued in Chap. 4 on social institutions) tend to claim dogmatically the spontaneous order out of the seemingly chaotic situation in the free market (without government intervention), but the Great Depression proved them terribly wrong, as John Maynard Keynes once famously said that "we are all dead in the long run", if naively waiting for the free market to sort things out by way of its mysterious magic to reach the illusive equilibrium. (BN 2006)

(b) Secondly, it commits the Humean naturalistic fallacy, in that one confuses "is" with "ought". In other words, even should there be order emerging out of the moral interactions of myriad individuals, why should this order be necessarily desirable?

(c) Thirdly, it dismisses too much the role of reason in the formation of morality, since even David Hume (1967) argued in *The Treatise of Human Nature*, that reason is still important in relation to two essential functions by telling us, firstly, the inconsistency among our beliefs and values, and secondly, the one between our means and ends in life.

(d) And fourthly, it also does not explain why the emergent moral behavior appears in the way that it does, other than just assuming that somehow it emerges out of the web of complexity in the moral interactions among myriad agents at the micro-level.

After all, as is often the case, "calling a phenomenon emergent is sometimes used in lieu of a more meaningful explanation". (WK 2006g)

5.4. Complexity and Epistemology

The debate on cultural complexity takes a different (but related) turn when the issue of epistemology is concerned. In the field of epistemology, the contention can be illustrated by way of two case studies.

They are, namely, (5.4.1) emergentism and reductionism and (5.4.2) problem shifts, and complex justificationism—to be discussed hereafter, in that order.

5.4.1. Emergentism and Reductionism

In *FPHC* (2004), I already argued that the debate between epistemic emergentism and reductionism is falsely structured and should be transcended. My stand here is that neither side wins and both are to be replaced by an alternative approach of mine.

More specifically, I suggested that, with the nature of consciousness as a case study of complex phenomena, "both epistemic reductionism and emergencism are equally unsatisfactory. The former often privileges the lower levels (e.g., chemistry and physics) without sufficient attention to the higher levels of explanation (e.g., psychology, sociology, culture studies). The latter, on the other hand, has the merit to include the higher levels but is often unable to come up, in a convincing way, with an underlying mechanism linking the different levels, or, in a different but tricky way, with a self-organizing and structured internal relation, for instance". (P. Baofu 2004: 271)

What then is the alternative? My theoretical contribution here can be summarized in this way: "The alternatives may not be something which either side wants to readily accept, in that the phenomenon of emergence in consciousness [as a case study here] is possible to be either epistemologically or ontologically unexplainable, or both. To be epistemologically unexplainable means that something may not be explained now (because of some 'hidden variables' to be discovered), within the constraints of current technological resources and theoretical frameworks but is explainable in principle (maybe sometime in the distant future). And to be ontologically unexplainable refers instead to the nature of some truly indeterministic (random) events, without the existence of hidden variables (or even some 'unrecognized' levels) at all to be blamed. (R. Hazen: 2001)" (P. Baofu 2004: 271-2)

But this is not to favor indeterminism against determinism, since my approach is to transcend the two as well, to be replaced with my ontological theory of "existential dialectics", as I clearly wrote: "One way to transcend the debate between epistemic reductionism and emergencism is to make use of the strengths of each side and to avoid the weaknesses of each, while accepting the possibility, though only a possibility, that the phenomenon of emergence may well be epistemologically and/or ontologically unexplainable, in that some truly indeterministic (random) events can well be part of reality in the cosmos after all, without having the need to appeal to any mysterious forces (or any other superstitious beliefs). After all, quantum mechanics, as an analogy, does not rule out this possibility....This position is consistent with my methodological holism, just as other three false dichotomies (i.e., epistemic subjectivism vs. non-subjectivism, epistemic objectivism vs. historicism, and epistemic relativism vs. absolutism) are to be transcended as well...." (P. Baofu 2004: 272)

More about the methodological and ontological status of complexity will be addressed in the next chapter, Chap. 6.

5.4.2. Problem Shifts, and Complex Justificationism

With the theoretical background of my previous books in mind—a more interesting aspect of the impact of complexity theory is its relation to problem shifts in epistemology, especially in regard to complex justificationism in the context of complexity theory.

A good illustration is the work by Robert Cutler (2002) on the nature of problem shifts in contemporary epistemology under the impact of complexity theory.

To understand the new epistemology under the influence of complexity theory, it is useful to start with an analysis of "epistemogony", as Cutler put it, which refers to different theories of epistemology, just as "a cosmogony may generate a class of theories of cosmology, or Hesiod's Theogony generated the class of theologies that are collectively called classical Greek mythology". (R. Cutler 2002)

Traditionally, for Cutler, there are three main theories of epistemology in the epistemogony of scientific realism, and they are the ones worked out by Karl Popper (1959), Thomas Kuhn (1962), and Imre Lakatos (1970).

The three different epistemologies here in the epistemogony of scientific realism have one thing in common, in that they have three main components concerning the logic of doing science, namely, (a) "a logic of hypothesis generation", (b) "a logic of hypothesis testing (i.e., a logic of the process of confirmation)", and (c) "a logic of generating consequences from (dis)confirmation". (R. Cutler 2002)

Since the three fall under the epistemogony of scientific realism, each of the three types of logic is either inductive or deductive, and at least two of the three must be deductive, as Cutler (2002) thus stipulated.

As shown in *Table 5.2*, the addition of complexity theory to the debate reveals something interesting, in that there is a "problem shift" in doing science, as Culter (2002) claimed. Let's consider each of the four epistemologies in more detail hereafter.

5.4.2.1. *Falsificationism*

The epistemology of falsificationism as advocated by Karl Popper is deductive in all of the three logics.

Popper criticized the empiricist (mostly positivist) approach of verificationism "that requires a (non-analytic), meaningful sentence to be either verifiable or falsifiable". (WK 2006ff)

Instead, Popper argued that the conventional "[i]nductivist methodology supposed that one can somehow move from a series of singular existential statements to a universal statement. That is, that one can move from 'this is a white swan', 'that is a white swan', and so on, to a universal statement such as 'all swans are white'. This method is clearly deductively invalid, since it is always possible that there may be a non-white swan that has somehow avoided observation". (WK 2006ee) Verification is thus not possible for Popper, because of this classic "problem of induction".

Instead, Popper's falsificationism treats all "empirical statements" to allow "logical counterexamples", in that "that no empirical hypothesis, proposition, or theory can be considered scientific if it does not admit the possibility of a contrary case". (WK 2006ee) Popper therefore thought that his falsificationism was an answer to the problem of induction.

But “some philosophers of science claim that science is based on such an inductive method”, in that scientific theories can allow exceptions, for different reasons.

For instance, Alan Sokal (1997) and Jean Bricmont thus criticized Popper in their book titled *Fashionable Nonsense*: “When a theory successfully withstands an attempt at falsification, a scientist will, quite naturally, consider the theory to be partially confirmed and will accord it a greater likelihood or a higher subjective probability....But Popper will have none of this: throughout his life he was a stubborn opponent of any idea of 'confirmation' of a theory, or even of its 'probability'...[but] the history of science teaches us that scientific theories come to be accepted above all because of their successes”, even though the successes are not conclusive or 100%.

5.4.2.2. *Paradigm Shifts*

If Sokal and Bricmont disagreed with Popper, so did Kuhn.

What distinguishes Kuhn’s theory of paradigm shifts from Popper’s falsificationism is that, for Kuhn in *The Structure of Scientific Revolutions* (1962), hypothesis generation, while trying to defend a given paradigm against falsification by the appeal to ad hoc hypotheses, at times (as in “extraordinary science”, as opposed to “normal science” in ordinary circumstances) leads, even if inadvertently, to the change into a new worldview (or new paradigm) not compatible with the old one, because the new one is capable to resolve old problems (anomalies) that the old paradigm could not, although this shift is not easy and often takes many years to achieve.

Hypothesis generation, for Kuhn, is thus inductive towards new paradigms, not deductive from the old ones—in Cutler’s interpretation.

5.4.2.3. *Research Programs*

There are some, however, who want to defend Popper, albeit in different degrees and different ways. A good example is Lakatos.

Lakatos's version of research programs tries to defend, partially in a way, Popper's falsificationism by walking a middle way against Kuhn, in arguing instead that hypothesis testing (or the process of confirmation) is inductive, contrary to the deductive tendency in Kuhn's theory of paradigm shifts in relation to hypothesis testing (and, for that matter, in Popper's falsificationism).

While acknowledging that hypothesis testing is never complete or conclusive, Lakatos distinguished those results which crack the "hard core" of a research program and those which do not.

For instance, Lakatos proposed the so-called "sophisticated methodological falsificationism" (in order "to save Popper from Kuhn"), in which "auxiliary hypotheses and other elements are generated in the 'protective belt' surrounding the research program's '(negative) heuristic', which in turn insulates its 'hard core'". (R. Cutler 2002) In this sense, hypothesis generation tends to be deductive (from existing research programs), both for Lakatos and for Popper, but not for Kuhn.

Yet, unlike both Popper and Kuhn, Lakatos argued that hypothesis testing (or the process of confirmation) can be inductive, in that, when the "hard core" of a research program is not successfully protected (or when it is finally "cracked"), a new research program emerges over time.

Here is the occurrence of a "problem shift" into a new research program different from the old one.

5.4.2.4. *Complex Justificationism*

The novelty of complexity theory is that, as Cutler (2002) argued, the interactions among different units in a complex system can add up something different at the macro-level, even contrary to the intentions of individual agents at the micro-level (or scientists in the scientific community).

In the case of Lakatos's idea of research programs, Cutler (2002) claimed that "this 'methodology' is intrinsically incomplete, because the capacity for modification of a research program's protective belt in Lakatos turns out to be equivalent to the adjoining of Peirce's Law to the negation system called 'simple refutability'. According to simple refutability, a system is falsified if any one of its elementary propositions is falsified. (Simple refutability is equivalent to what Lakatos called 'dogmatic falsificationism'. In logico-mathematical contexts, it is also called 'minimal negation'".

In other words, "[c]omplexity science identifies two ways for such additional propositions to find their way into the protective belt. The first possibility is that an elementary proposition in the heuristic is considered multiple rather than singular and is split into two or more constituent elements, one of which may be taken outside ('alienated from') the heuristic into the protective belt....The second possibility is that an elementary proposition in the heuristic is considered—or found to be multiple rather than singular....In these latter cases, a proposition originally thought to be elementary generates one or more new propositions within the Lakatosian heuristic itself. These newly generated propositions are emergent in the complexity-informed sense and must be considered elementary rather than composite. In either instance, the content of the heuristic is altered.....This representation opens the door to a complexity-informed consideration of the growth of scientific knowledge. If one sought a Lakatosian name for the proof methods of complexity science, 'complex justificationism' would be appropriate".

This new model is essentially inductive in the logic of generating consequences of (dis)confirmation, since it takes into account of different layers and actors in a complex system, such that the emergent properties at the macro-level differ drastically from what the individual actors (or scientists, in this example) do in their research programs. And therefore the consequences from (dis)confirmation cannot be exactly predicted.

Even when individual scientists try to come up with some ad hoc hypotheses to protect the hard core of a research program, the interactions among them can create something else (e.g., the cracking of a system when it is inundated with too many ad hoc hypotheses trying to save the hard core of a research program) not exactly predictable at the micro-level.

In the end, the consequences from (dis)confirmation are hard to be exactly generated, in light of the uncertainty in emergent properties.

5.4.2.5. *A Critical Assessment*

Yet, this idea of "complex justificationism" with the use of complexity theory by Cutler is controversial indeed. Consider, say, two criticisms for illustration.

(a) Firstly, Cutler's classification of the different epistemologies as shown in *Table 5.2* is too rigid and thus misleading. It is highly dangerous to rigidly classify a philosopher of science, be it Kuhn, Lakatos, or Popper, as being inductive or deductive in a given logic.

For instance, while Kuhn's logic of hypothesis generation can be regarded as "inductive" in its contributive role towards a new paradigm over time (as in "extraordinary science"), it can also be looked at with a deductive eye when scientists propose ad hoc hypotheses to defend an existing paradigm in what Kuhn called "normal science".

Thus, the epistemogony that Cutler used is too rigid, in putting things in an absolute framework, or in a black-or-white perspective. In this way, the distinction of "complex justificationism" as a unique contribution of complexity theory to contemporary epistemology is not as amazing or impressive as it might have appeared, if different epistemologies are not treated with such a rigid black-or-white dichotomy.

(b) And secondly, any emergent property (e.g., the cracking of the hard core of a research program at the macro-level) in a complex system needs to be further explained, since the appeal to the networks of scientists, their activities, and ideas is still begging the question concerning the explanation of the emergence itself, as "calling a phenomenon emergent is sometimes used in lieu of a more meaningful explanation". (WK 2006g)

In fact, the complexity of these enormous networks of interactions among myriad scientists is far from clear.

5.5. Complexity and Aesthetics

The last cultural complexity to be addressed here concerns the relationship between complexity and aesthetics. A vital implication here is to rebuke the reductionistic tendency by some scholars on complexity, with Wolfram as a latest example, who goes so far as to treat artistic works (like "postmodernism") from the reductionistic standpoint of the rule 110 cellular automaton. (WK 2006t)

Nothing is more reductionistic than this naïve attempt in computational aesthetics. Anyone who tries to understand paintings, for example, solely from the perspective of the rule 110 cellular automaton (as in, say, mathematics and computability theory) will not be able to appreciate artistic works much, other than from a narrow (and even irrelevant at times) standpoint of outside disciplines.

Consider two case studies, namely, (5.5.1) beauty and fractal attractors and (5.5.2) adaptational complexity and the beauty of wholeness—to be addressed hereafter, in that order.

5.5.1. Beauty and Fractal Attractors

As a start, the use of complexity theory for the understanding of aesthetics is neither new nor pointless, however. On the contrary, it has a long history and is useful, though up to a certain point.

5.5.1.1. *The Golden Mean*

For instance, the classic rule of the "Golden Mean" for simple (not complex) properties in aesthetic appreciation is well known. But one has to wait until later, especially (though not exclusively) in modern times, to see more and more systematic uses of complexity in aesthetics, and some good instances are the works by Gustav Fechner (1876) and D. E. Berlyne (1960). (F. Abraham 2006)

5.5.1.2. *Experimental Aesthetics*

Berlyne built upon the "work on the experimental aesthetics of simple visual forms that began with Fechner's Vorschule der Äesthtik" and came "to confirm the view that some intermediate degree of complexity produces the most pleasing effect and the extremes of simplicity or complexity are distasteful". (F. Abraham 2006)

G. D. Birkhoff (1933) even went so far as to provide a precise formula for aesthetic value (M) as "a function of complexity C of the image (diversity or numerosity) upon which attention and tension depended, and order (unity, due to properties such as symmetry) of the image, upon which (as updated by Graves [in]...1951) resolution of the tension depended". (F. Abraham 2006)

In other words, Birkhoff's equation of beauty by the use of complexity is, M = O/C. This mean that "aesthetic value was proportional to order, and inversely proportional to complexity. Very shortly, there were attempts to test this theory (Eysenck...[in] 1941 ...[and] Davis...[in] 1936) which found...that there was a maximum of aesthetic judgment at intermediate values of Birkhoff's M...." (F. Abraham 2006)

Later, a collective work by Frederick Abraham (2006), Julien Sprott, Olga Mitina, Maureen Osorio, Elvie Dequit, and Jeanne Pinili followed on the same footsteps of exploiting complexity for aesthetic experimentation by proposing the scale of F, which "treats complexity as a single dimension stretching between order and complexity, rather than assuming a composite function...."

More specifically, they made use "of images of chaotic attractors as a function of their fractal dimension (F)", since fractals are often used in the study of complexity theory (and, for that matter, chaos theory), because a fractal has unusual properties well suited for the study of complexity like (a) "fine structure at arbitrarily small scales...too irregular to be easily described in traditional Euclidean geometric language", (b) "self-similar (at least approximatively or stochastically)", and (c) "simple and recursive" in definition. (WK 2006w; F. Abraham 2006)

5.5.1.3. *The Danger of Reductionism*

But the main problem here is the reductionistic tendency of treating aesthetic appreciation from the sole vantage point of complex geometric forms.

Remko Scha (1993) and Rens Bod once aptly commented on the danger of this reductionistic tendency in computational aesthetics: “Though the esthetic experience remains one of the most enigmatic side-effects of human perception, several mathematical models have been proposed which assign to visual patterns a 'beauty coefficient'—a number that is intended to correlate with the degree of esthetic pleasure the pattern evokes. Such theories seem a little naive, because they focus on a quantitative and absolute beauty judgment. They disregard the qualitative aspects of specific esthetic experiences, and do not account for the context-dependence and variability of beauty-judgments”.

More specifically, in relation to some of the works as previously cited, Scha (1993) and Bod rightly criticized them as “extremely narrow”. For instance, “Birkhoff's 'Esthetic Measure' is in fact merely an 'orderliness-coefficient,' and this characterization also applies to the information-theoretic versions of this notion based on Bense or Leeuwenberg. All these models identify the experience of beauty with the perception of formal regularities in the object that is observed, and they correlate the intensity of the experience directly with the number of regularities”. (R. Scha 1993)

I also already proposed a non-reductionistic way of understanding the nature of beauty and ugliness from a more holistic dimension in both *FHC* (2 volumes) and *FCD*.

As an illustration, in Table 9.3 of *FCD* (built upon the work of *FHC*), I proposed “a multi-faceted framework for the analysis of the sublime and the beautiful”, with such criteria as “moment” (e.g., “immersion, irruption, identification”), “form” (e.g., “geometry, abstraction, mixture”), “content” (e.g., “God, power, Nature, the body, the city”), “technique” (e.g., “background, motif, patterns, structure, affect”), “typology” (e.g., “Sacral, Courtly, Bourgeois”), “style” (e.g., “Classical, Renaissance, Baroque, Impressionist, Realist”), “internal critique” (e.g., “Critical Reflection, Aestheticism, Deconstructionism, Classism”), and “external critique” (e.g., “Feminism, Marxism, Psychoanalysis, New Historicism, Pathology”).

The danger of academic chauvinism from one field or a few to the others is something to be guarded against. The fact that this time, in the present study, it is in the name of complexity does not justify it, any more than such a reductionistic fallacy was committed many times before in human history by other equally appealing slogans (e.g., God).

5.5.2. Adaptational Complexity, and the Beauty of Wholeness

The same critique can be applied, albeit in a different way, to understand beauty with the use of complexity in, say, architecture.

Christopher Alexander (2003), for instance, in "New Concepts in Complexity Theory: Arising from Studies in the Field of Architecture" proposed a way to appreciate architectural beauty with the use of complexity theory.

5.5.2.1. *Qualitative Value*

Alexander's starting point (2003) is that "value...cannot be separated from the main task of serving functional needs....Thus, aesthetics—dismissed as subjective in much contemporary science—lies at the core of architecture".

But what is something which is of aesthetic value in architecture? Alexander (2003) then suggested that it must be about "quality": "The very first thing any scientist would do, if trying to make a sensible theory of architecture, would be to recognize that there must be, at the bottom of it, a shared notion of quality, what we are, collectively, aiming for".

This "quality", when applied to architecture, refers to "a good system...that...helps both the systems around it and those which it contains. And the goodness and helping towards goodness is, in our ideal complex system, also reciprocal. That is, our good system, will turn out to be not only helping other systems to become good, but also, in turn, helped by the goodness of the larger systems around it and by the goodness of the smaller ones which it contains". (C. Alexander 2003)

5.5.2.2. *The Good of Wholeness*

This reciprocity draws from an insight in recursive function theory (on complexity), since it is well known that “surprisingly simple ideas, when applied recursively at a variety of nested levels, can have profound and effective consequences—and, often, surprising ones”. (C. Alexander 2003)

Thus, what is of good quality in architecture must involve a property of “wholeness”, capable of taking in account of the complex reciprocity between smaller and larger systems.

Alexander (2003) then proposed fifteen geometric properties of space to objectively measure this qualitative feature of wholeness for complex systems (as in architecture).

5.5.2.3. *Geometric Properties of Space*

Consider one of the fifteen geometric properties as an example here, namely, “boundary condition” in architecture.

Alexander (2003) thus explained: “Let me give an example. Boundaries, and especially thick boundaries with substance, can play a role in helping the goodness of a center, or in strengthening a center. This happens because, if two systems are interacting, the boundary condition is often turbulent or a source of possible confusion. When the boundary zone itself has dimension, it can then take on an 'in between' structure, which mitigates or smoothes out the potential interacting processes in the inner and outer zones”. (C. Alexander 2003)

When viewed from the larger perspective of emerging properties in complex systems, these geometric properties help us understand the interactions between the systems, to the extent that “deep adaptation” emerges as an important feature in good architectural quality.

5.5.2.4. *Deep Adaptation*

In Alexander’s parlance (2003), “[t]his concept [of deep adaptation]...is possibly the most fruitful point of contact between the theory of complex systems, and the problem of architecture”.

Deep adaptation here refers to the "the type of spatial adaptation which occurs between neighboring elements and systems, and which ultimately causes the harmonious appearance and geometrical cohesion we find in all living matter. Deep adaptation is the process whereby the landscape, or a system, or a plant, or a town, proceeds by a series of spatially organized adaptations in which each part is gradually fitted to the parts near it: and is simultaneously fitted by the whole, to its position and performance in the whole". (C. Alexander 2003)

5.5.2.5. *Adaptational Complexity in Architecture*

This then constitutes the beauty of adaptational complexity in architecture.

Alexander (2003) claimed that the resulting transformation of the world by way of applying these fifteen geometric properties should not be underestimated, since "the fifteen transformations...[are] the 'glues' of wholeness" and "these transformations do have the power to help reach new, and truly beautiful configurations, and I believe they do also have predictive force in helping to understand how naturally occurring complex adaptive systems find their way to truly beautiful new configurations".

A bold claim he made here indeed.

5.5.2.6. *Some Challenging Criticisms*

But adaptational complexity in architecture so understood by Alexander are entangled within a web of controversial problems. Consider, for instance, two main ones.

(a) Firstly, to achieve the beauty of wholeness as envisioned by Alexander would require a computational magnitude in architectural design that even Alexander (2003) himself acknowledged as extremely infeasible in practice.

Consider his confession: "In *The Nature of Order* (Book 3 appendix) I have made a crude estimate comparing the number of possible configurations in a given building design problem, with the number of those possible solutions that are likely to be well adapted—hence to have living structure. The ratio of these two numbers is truly astonishing. In my estimate there are, in all, $10^{2,000,000,000}$ possible configurations; and of these there are approximately $10^{1,998,000,000}$ good configurations. The absolute number of configurations both in the 'good' pile and in the 'all' pile, are immense—immense beyond imagining....But it is the ratio of the two numbers which staggers the imagination. The ratio between the two numbers is, in rough terms, about $10^{12,000}$. Further, although there are huge numbers of possibly good configurations, these good ones are sparsely scattered throughout configuration space, they are certainly not nicely grouped in any one part of configuration space. What this means is that the problem of finding the relatively good configurations is, in principle, a problem of staggering difficulty. It is not merely like finding a needle in a haystack. It is not even like finding a single particle, among all the particles in the known universe; that would merely be a problem of finding one particle among 10^{80}. This problem is inexpressibly large by comparison. The compactness of the written arithmetic expression $10^{12,000}$ belies the true immensity of the actual number. This task is so huge as to be almost unimaginable". (C. Alexander 2003)

(b) And secondly, another damaging critique here is that Alexander's computational aesthetics is essentially embedded within a "conservative" aesthetic orientation (or ideology) in favor of "symmetry", "fitness", "cohesiveness", "adaptation", "harmony", and similar features in complex systems.

Or, to understand this criticism better, just contrast Alexander's adaptational aesthetics for harmony with the "chance music" of John Cage in the latter's "anti-establishment stance", and one can easily spot Alexander on the Right Wing of the ideological spectrum and Cage on the Left Wing.

Cage once thus described his music as "purposeless play", because "this play is...not an attempt to bring order out of chaos, nor to suggest improvements in creation, but simply to wake up to the very life we are living...."

To understand further Cage's rebellious tendency against the "conservative" orientation of harmony, it is interesting to remember his encounter with his tutor, Arnold Schoenberg. Cage thus wrote in *Indeterminacy*: “After I had been studying with him for two years, Schoenberg said, 'In order to write music, you must have a feeling for harmony.' I explained to him that I had no feeling for harmony. He then said that I would always encounter an obstacle, that it would be as though I came to a wall through which I could not pass. I said, 'In that case I will devote my life to beating my head against that wall'”. (VM 2006)

The contrast between the two could not be clearer.

5.6. The Myth of Cultural Complexity

There is no substitute for knowledge and experience, in the end, without doing the homework as needed. The search for some underlying simplicity for complex phenomena, in one extremity, and for emergent myths, in another extremity of the same pole, are the two misleading polar tendencies in the reductionism/emergentism debate.

The illustration of complexity in culture here serves only as a convenient analysis of these two misleading tendencies in action. What then are the implications for the understanding of complexity and its future?

This is the question to be answered in the final chapter, to which we now turn.

Table 5.1. Cultural Complexity

- **Complexity and Religion**
  - Ex: Specified complexity and divine design
  - Ex: Self-Organization and evolution

- **Complexity and Morality**
  - Ex: Free will and incomplete information
  - Ex: Moral reciprocity, and the emergent world order

- **Complexity and Epistemology**
  - Ex: Emergentism and reductionism
  - Ex: Problem shifts, and complex justificationism

- **Complexity and Aesthetics**
  - Ex: Beauty and fractal attractors
  - Ex: Adaptational complexity and the beauty of wholeness

Notes: The examples in the categories are solely illustrative (not exhaustive), and the comparison is relative (not absolute), nor are they necessarily mutually exclusive. And some can be easily re-classified elsewhere. As generalities, they allow exceptions.
Sources: A summary of Chap. 5 of *FC*

Table 5.2. The Logics in the Epistemogony of Scientific Realism

Logic of:	*Karl Popper*	*Thomas Kuhn*	*Imre Lakatos*	*Complexity Theory*
Hypothesis Generation	D	I	D	D
Hypothesis Testing	D	D	I	D
Generating Consequences of (Dis)confirmation	D	D	D	I

Note: "D" stands for "deductive", and "I" refers to "inductive". See text for my critique of Cutler's classification here as presented in the table.
Source: A reconstruction from a table in R. Cutler (2002)

• Part Six •

Conclusion

• CHAPTER SIX •

Conclusion: The Future of Complexity

> Stephen Muggleton…argues [that computers]…will soon play a role in formulating scientific hypotheses and designing and running experiments to test them. The data deluge is such that human beings can no longer be expected to spot patterns in the data. Nor can they grasp the size and complexity of one database and see how it relates to another. Computers—he dubs them "robot scientists"—can help by learning how to do the job. A couple of years ago, for example, a team led by Ross King of the University of Wales, Aberystwyth, demonstrated that a learning machine performed better than humans at selecting experiments that would discriminate between hypotheses about the genetics of yeast.
>
> —*The Economist* (2006)

6.1. The Future of a Fad

What then is the future of this fad of complexity theory in our time (or more broadly speaking, this idea of complexity in general)—given what has been said so far in this book?

By way of a conclusion, I hereafter propose five theses, namely, (6.2) the first thesis on the partiality-totality principle, (6.3) the second thesis on the order-chaos principle, (6.4) the third thesis on the progression-regression principle, (6.5) the fourth thesis on the predictability/unpredictability principle, and (6.5) the fifth thesis on the post-human response—to be analyzed hereafter, in that order (and summarized in *Table 6.1*).

If other principles in existential dialectics are not listed above, it is not because they are not important but because they are already implied in relation to the discussion of the theses in question (as will be clear shortly).

6.2. 1st Thesis—The Partiality-Totality Principle

My first thesis can be called, in the absence of better words, *the partiality-totality principle*—which is based on my sophisticated methodological holism, as already worked out in *FPHC* and later elaborated in other subsequent books of mine as "methodological holism" (as already introduced in Chap. 1).

With this background in mind and the analysis of complexity in this book—the partiality-totality principle suggests that any analysis of a phenomenon in the world requires both the examination of the individual parts and the whole of them (with the whole as being not the sum of the parts), without privileging the whole as more important than the parts, or vice-versa (that is, the parts as more important than the whole).

In fact, the partiality-totality principle targets two kinds of misleading methodologies as used over the ages, that is, again in the absence of better words, what I want to call *reductionism* and its opposite, *reverse-reductionism*, which can take four major forms in relation to concept, theory, methodology, and ontology (as summarized in *Table 6.2*).

In the present context of complexity, let me just discuss only two of them for illustration, namely, (a) methodological reductionism and (b) ontological reductionism. And the reader is expect to consult *Table 6.2* for other forms of reductionism and reverse-reductionism (as already worked out in my previous works).

6.2.1. Methodological Reductionism

The first type can be called *methodological reductionism*, in which a researcher privileges a form of research method over others, in that the method in question is used to dismiss alternative ones without trying to learn from them without reducing them from the perspective of the method in question.

In the literature of complexity theory, for instance, it has long been dominated by the *quantitative* analysis (with the use of mathematics, logic, raw data, and graphs) of the nature of computation. There are two sub-types to be mentioned here.

One type of quantitative analysis in regard to the nature of computation stresses the use of data analysis and mathematical proofs, for instance, as engineers "seek…to build practical systems using computations [in the case of data analysis]; and mathematic[ians]…seek…to prove theorems about computation [in the case of mathematical proofs]". (WK 2006t)

A second sub-type prefers to use the graphical analysis of computation instead, with Wolfram's work as a latest example, since his method focuses on graphs in the world of computation to be "visualized as directly as possible, and exhaustively examined by the thousands or more". (WK 2006t) For this reason, some of his critics in the first sub-type "has…criticized [him] for being heavily visual, with much information conveyed by pictures that do not have formal meaning" in his book. (WK 2006t)

By contrast, my methodological holism here does not reject the usefulness of the two sub-types of quantitative analysis above (be it numerical, formal, or graphical), while at the same time making good use of *qualitative* analysis too.

In fact, my book here is an example par excellence, which uses much of qualitative argumentation at the theoretical level—and at the same time relies on quantitative findings by others (e.g., Heisenberg's Uncertainty Principle in Chap. 2, Gödel's incompleteness theorems in Chap. 3, Wolfram's rule 110 cellular automaton in Chap. 4, and fractal attractors in Chap. 5).

Consequently, unlike both qualitative and quantitative methods of analysis, however, my methodological holism does not privilege or dismiss any method (including mine), insofar as it can enhance our understanding of the world in a given case of usage.

In fact, my methodological holism appeals to all relevant levels of analysis and all relevant forms of analysis (with examples in the entire domains of human knowledge ranging from the natural sciences through the social sciences to the humanities—as already introduced in Chap. 1 and summarized in *Table 6.2* and *Table 6.3*).

6.2.2. Ontological Reductionism

A second type of reductionism in the field is what I call *ontological reductionism*, insofar as it automatically privileges some level(s) of analysis as superior over others, such that the opposing ones are often either ignored or dismissed as less important in overall contribution (or even as outright wrong).

In fact, the debate between emergentism and reductionism (as analyzed in the previous chapter, Chap. 5) is an excellent example, with the former favoring the higher levels of analysis (as in psychology, sociology, or anthropology) and the latter privileging the lower levels (as in physics, chemistry, and biology). In so doing, each camp presupposes an ontological privilege in favoring some levels as being more "real" than others.

For instance, those in emergentism (like William Dembski with his idea of "specified complexity" as analyzed in Chap. 5) often reject or dismiss the reductionist approach.

By the same logic, albeit in the opposite direction, those in reductionism (like Stephen Wolfram with his search for the underlying simplicity for all complex systems—as a form of reductionism) do likewise against the conventional forms of emergentism.

My methodological holism favors neither emergentism nor reductionism but learns from each of them without identifying with either of them, since my methodology makes use of the merits of different levels of analysis in understanding reality, be they in the natural sciences, the social sciences, or the humanities (as this book, and all previous ones of mine, have tried to do).

6.3. 2nd Thesis—The Order-Chaos Principle

The second thesis of mine is that both order and chaos are vital in the process of change in the world. In fact, this thesis is related to another principle in existential dialectics already worked out previously in *BCPC*, that is, the change-constancy principle on the evolution of time (or more elegantly, on the dynamics of space-time).

The distinction between the two principles is that the change-constancy principle only says that change occurs over time, even when constancy is also allowed, but does not by itself suggest how change occurs over time, while the order-chaos principle specifically gives a role to chaos as the novelty for change.

With this clarification in mind—some scholars in the field of chaos theory study the change in the initial conditions of a complex system in order to learn the patterns of order emerging over time. The same can be said about the search for emergent properties in complexity theory, for instance.

But this preference for order is biased, since they do not give sufficient attention to the vital role of chaos in the transformation of the world (without somehow reducing it for the understanding of order).

The scientific search for order in the world is often a hidden bias in its ontological obsession with order, since chaos is often treated as the "bad" guy, with order as the "good" guy (for the end goal of science).

And "[s]cience backs up the notion that mess has gotten a bad rap, starting with something you learned in high-school physics: anything you do increases the universe's entropy—that is, disorder....But this pervasive bias toward maximum organization, order and neatness is often irrational and ineffective, typically causing more problems than it solves. A certain amount of mess and disorder is usually not the terrible thing we make it out to be, and in many cases it actually improves things. Our failure to recognize this simple truth leads us astray in all sorts of ways, big and small". (D. Freedman 2007)

For instance, some recent scientific research findings suggest, counter-intuitively, that even "the human mind—and a lot of other things, as it turns out—often work better not when they're neat and highly ordered, but rather when they operate in a messier fashion. That principle may apply not only to how we live and work, but also to how people around the world deal with regional instability, terrorism and natural disasters", so "[r]andomness, disorder and mess can be beneficial…." (D. Freedman 2007)

My suggestion of *the order-chaos principle* here is an addition to the other three principles in my existential dialectics, which I worked out in my previous works (especially, though not exclusively, in *FPHC* and summarized here in *Table 6.5*).

The other three principles are, namely, (a) the regression-progression principle (on the "direction" of history), (b) the symmetry-asymmetry principle (on the "relationships" among existents), and (c) the change-constancy principle (on the "evolution" of time, or more elegantly, on the "dynamics" of space-time).

Lest any misunderstanding occurs, it should be stressed that all these principles are *not* reductionistic, since in accordance to my methodological holism, all relevant levels of analysis in the myriad fields of human knowledge are to be included in any study of a given phenomenon, and the ontological level here for the principles in existential dialectics is only *one* level among many to be considered for research and development.

This important clarification aside—this latest principle, that is, the order-chaos principle, is about *the process of change*—in that both order and chaos co-exist in their recurrent interactions for the dynamics of change in the world.

Neither order nor chaos is the final end of the world, and one is not to be treated as the means for the other in the transformation of things. Both are fundamental in their recurrent dialectical interactions with each other over time, without reducing one for the other.

Some scholars even tried to understand what is now known as "phase transition" between order and chaos, and good instances are what were already introduced in Chap. 2, namely "the edge of chaos" in the work of C. Langton (1990), the "chaotic edge" in the one of D. Green (1994)—and, recently, the "adaptive walks between extremes of immobility...and disorganization" by J. Brody (2000). In this light, W. Freeman (1992) rightly said that "chaos may be an important source of novelty in nature". (D. Green 2001)

But my order-chaos principle goes further, in stressing their dialectical interactions in the process of change. Yet, this does not mean that both order and chaos are equal in their dialectical interactions.

In fact, the order-chaos principle is also related to another principle in existential dialectics, namely, the symmetry-asymmetry principle, which suggests, in the present context, that one can be more vital than the other at a given point of time, while the other can be more important than one at another point of time, or both of them can be relatively so at a different point of time. Or, to put it in a different way, the "compromise fallacy" that I referred to in *BNN* is relevant here, albeit as an analogy.

The same symmetry-asymmetry constraint can be applied to, say, related principles like the regression-progression principle (see below) and the predictability-unpredictability principle (as will be clear shortly).

6.4. 3rd Thesis—The Regression-Progression Principle

My third thesis is to appeal to the regression-progression principle in my existential dialectics (which was already worked out in my previous works, again, especially in *FPHC*) for the purpose here on the topic of complexity, in that a better understanding of complexity in the world is to stress the nature of historical relativity, in being progressive and regressive at the same time.

Three illustrations suffice here to clarify this third thesis of mine.

(a) Firstly, the problematic of intractability in computational complexity theory (as introduced in Chap. 1) is a good illustration of this dilemma, in that the more complex the problems are to be solved, the more intractable they are, because of space and time constraints.

In fact, Bremermann's fundamental limit (as discussed in Chap. 3) is another indication of the constraints on computation.

Thus, in spite of the technological advance in computer power, Donald Hoffman thus wisely reminded us, albeit in an amusing way: "You can buy a chess machine that beats a master but can't yet buy a vision machine that beats a toddler's vision". (WK 2006x)

(b) Secondly, the ancients might know less than what we now do about complexity, for instance, because their society and culture in pre-industrial antiquity did not demand such a need, when compounded with the relatively more limited resources constraining them to resolve relatively less complex problems at the time.

By the same logic, future intelligent life will likely know more about complex phenomena than what we now do, because future society and culture require such an understanding, with more resources available at their relatively more technologically complex level than ours for research and development.

However, as this is an important point to remember, some fundamental questions about life and the world still remain to be answered for them, just as much as they are for us.

The big questions since the start of civilization remain, and examples may include, say, Is there God? Or, was there a world before this world? And, of course, one can add one's own preferred list of still unanswered profound questions here.

In hindsight, it is worth remembering that many of the "great books" in history were written in the Classical Golden Age of Antiquity, not in our contemporary time, even when we are blessed with all the scientific achievements in knowledge on complexity by way of cybernetics, chaos theory, catastrophe theory, and complexity theory, just to name four examples.

With the clever use of their imagination and intuition (plus everyday observations), for instance, the ancients were still able to come up with great ideas about complex phenomena, even when they lacked the scientific resources that the post-moderns in our time are privileged to possess.

(c) And thirdly, to know more about some technical issues is not to say that people in the more advanced culture and society must be happier. On the contrary, there is some truth to the statement that "ignorance is bliss"—even though the counter-statement that "knowledge is power" is not less sensible.

My 2-volume work of *FHC* is to reveal, among many other issues, the double sword of liberation and deconstruction in relation to values and beliefs confronting modernity and its post-modern counterpart, even when the moderns and now the post-moderns succeed—not without some regression at the same time, however—in understanding more about the complexity of the world than the pre-moderns.

6.5. 4th Thesis—The Predictability-Unpreditability Principle

The fourth thesis is that both predictability and unpredictability have a major role to play in the occurrence of things, so that neither determinism nor indeterminism wins the centuries-old fight.

In the end, both predictability and unpredictability await intelligence life like us. There is some truth to the statement that the more we know, the more problems we raise about what we know.

There are events which are predictable, just as there are those which are not. Or what is regarded as unpredictable at one point in time may turn out to be predictable later, and, conversely, what is deemed as predictable may turn out to not be so predictable. Even in predictability, outcomes are subject to uncertainty, the degree of which varies from case to case.

For example, in the Newtonian age of classical mechanics, the universe was assumed to be governed by deterministic laws. Yet, with the advance of quantum mechanics in the 20th century, the uncertainty principle mocks Einstein's naivete that God does not play dice with the world.

In another illustration, the Christians have predicted for thousands of years about the Second Coming, but it has been nowhere to be seen—just as the Marxists used to predict about the inevitable replacement of capitalism by communism, but the end of the Cold War has much silenced them about this.

By the same logic, but in the opposite direction—in the older days, people found it amazingly hard to engage in the business of weather prediction (although climate prediction is often a bit easier, both then and now).

Yet, with the discovery of the butterfly effect in chaos theory, it is now understood that there is some emergent order over time even in weather occurrence, so that weather prediction is not next to being impossible as was once thought, although the science of meteorology is far from the state of perfection.

Another good illustration is that in the older days, people could not predict whether or not a pregnant woman would bear a boy or a girl, but nowadays the technological advance in Obstetric Ultrasound Scanning can easily tell whether the fetus is a boy or a girl, well before birth—or "an early term sonogram" can show if it is a boy or a girl. (S. Woo 1995; YN 2007)

The difficulty here is for us to recognize which ones are predictable and which ones are not. Even in predictability, outcomes are subject to uncertainty. This challenge is not trivial, since there are eminent scholars, like Albert Einstein, who still insisted unto the end of his life, even when confronted with contrary evidences, that "God does not play dice with the universe". (PW 2005)

I thus side neither with the determinists nor the indeterminists, and neither with the emergentists nor the reductionists.

Both predictability and unpredictability are here to stay.

6.6. 5th Thesis—The Post-Human Response

My last thesis here is about the response to complexity by the successors of humans, or what I already originally proposed in *FHC* and other books of mine, namely, "post-humans" in the context of human extinction at some distant point of "after-postmodernity".

Perhaps a good case in point here concerns two special forms of post-humans, in what I originally suggested in *FCD* and *FPHC* (and, for that matter, other subsequent books of mine as well) as "floating consciousness" and "hyper-spatial consciousness".

The spread of floating consciousness across the cosmos and beyond (without the bio-chemical forms as conventionally understood on earth) in the distant future is a good possibility to illustrate the mastering of complexity in the cosmos in a way that our world has never known.

And the other one, that is, the emergence of hyper-spatial consciousness in multiple dimensions of space-time that our world has also never experienced, is another good candidate.

These are two good examples of the post-human response to complexity that I have in mind, in terms of understanding and manipulating them in a way more suitable to the ultimate conquest of intelligence life in the world unto multiverses.

Yet, the post-humans, even in the most distant future, will still be subject to the constraints as imposed by the first four theses here, in the present context of complexity—or more generally, to the constraints as imposed by the principles in existential dialectics (albeit only at the ontological level, as other levels of analysis are needed too).

6.7. An Epilogue

With this caveat in mind—in the very end, should there be a god (either literally or figuratively), perhaps a more scientific way (that is, without any religious and mystical contamination) to express it (in a less imposing or more impartial spirit) is this post-human response to complexity by way of mastering it for the ultimate existence of intelligence life in the cosmos and beyond.

Unfortunately (or, in a twist of logic, fortunately), there is a small footnote to add, in that there will be neither utopia nor dystopia in this godlike post-human world of conquering complexity in the most distant age to come that no one has ever known in all history hitherto existing.

If the idea of complexity becomes a fad in the community of scholars on complexity theory in our contemporary time, it is still a big step for current humans to wrestle with the understanding of complex phenomena under heaven and earth, even when its time as a fad will expire some day.

Yet, it is only a small step for distant posterity—and, especially though not exclusively, post-humans—to move on with the greater challenge to understand the long odyssey of their infinitely more complex life world in the most distant future history to come that our world has never known....

Table 6.1. The Dialectic Theory of Complexity (Part I)

- **1st Thesis: The Partiality-Totality Principle**
  - This principle is against the varieties of reductionism and reverse-reductionism. Below is a summary of two forms of reductionism only. See *Table 6.2* for more.
  - *Methodological Reductionism*
    - A researcher privileges a form of research method over others, in that the method in question is used to dismiss alternative ones without trying to learn from them without reducing them from the perspective of the method in question. In the literature of complexity theory, for instance, it has long been dominated by the *quantitative* analysis (with the use of mathematics, logic, data, and graphs) of the nature of computation.
    - By contrast, my methodological holism here does not reject the usefulness of the two sub-types of quantitative analysis above (both written and graphical), while at the same time making good use of *qualitative* analysis too. Consequently, unlike both quantitative and quantitative methods of analysis, however, my methodological holism does not privilege or dismiss any method (including mine), insofar as it can enhance our understanding of the world in a given case of usage. In fact, my methodology appeals to all relevant levels of analysis and all relevant forms of analysis in all domains of human knowledge.
  - *Ontological Reductionism*
    - A researcher privileges some level(s) of analysis as superior over others, such that the opposing ones are often either ignored or dismissed as less important in overall contribution (or even as outright wrong).
    - My methodological holism favors neither emergentism nor reductionism but learns from each of them without identifying with either of them. My methodology makes use of all relevant levels of analysis in all domains of human knowledge.

(continued on next page)

Table 6.1. The Dialectic Theory of Complexity (Part II)

- **2nd Thesis: The Order-Chaos Principle**
  - Both order and chaos are vital in the process of change in the world. In fact, this thesis is related to another principle in existential dialectics, that is, the change-constancy principle on the evolution of time (or more elegantly, on the dynamics of space-time).
  - The distinction between the two principles is that the change-constancy principle only says that change occurs over time, although constancy is also allowed, but does not by itself suggest how change occurs over time, while the order-chaos principles specifically gives a role to chaos as the novelty for change.
  - Some scholars in the field of chaos theory study the change in the initial conditions of a complex system in order to learn the patterns of order emerging over time. But this preference for order is biased, since they do not give sufficient attention to the vital role of chaos in the transformation of the world (without somehow reducing it for the understanding of order).
  - The scientific search for order in the world is often a hidden bias in its ontological obsession with order, since chaos is often treated as the "bad" guy, with order as the "good" guy (for the end goal of science).
  - The order-chaos principle is about *the process of change*, in that both order and chaos co-exist in their recurrent interactions for the dynamics of change in the world. Neither order nor chaos is the final end of the world, and one is not to be treated as the means for the other in the transformation of things. Both are fundamental in their recurrent dialectical interactions with each other over time, without reducing one for the other, although they are not necessarily equal on all occasions, as some may be more so than the other at a given point in time.

(continued on next page)

Table 6.1. The Dialectic Theory of Complexity (Part III)

- **3rd Thesis: The Progression-Regression Principle**
  - A better understanding of complexity in the world is to stress the nature of historical relativity, in being progressive and regressive at the same time.
  - Firstly, the problematic of intractability in computational complexity theory is a good illustration of this dilemma, in that the more complex the problems are to be solved, the more intractable they are, because of space and time constraints. In spite of the technological advance in computer power, Donald Hoffman thus wisely reminded us, albeit in an amusing way: "You can buy a chess machine that beats a master but can't yet buy a vision machine that beats a toddler's vision". (WK 2006x)
  - Secondly, the ancients might know less than what we now do about complexity. However, it is worth remembering that many of the "great books" in history were written in the Classical Golden Age of Antiquity, not in our contemporary time, even when we are blessed with all the scientific achievements in knowledge on complexity by way of cybernetics, chaos theory, catastrophe theory, and complexity theory, just to name four examples. With the clever use of their imagination and intuition (plus everyday observations), for instance, the ancients were still able to come up with great ideas about complex phenomena, even when they lacked the scientific resources that the post-moderns in our time are privileged to possess.
  - Thirdly, to know more about some technical issues is not to say that people in the more advanced culture and society must be happier. My 2-volume work titled *The Future of Human Civilization* is to reveal, among many other issues, the double sword of liberation and deconstruction in relation to values and beliefs confronting modernity and its post-modern counterpart.

(continued on next page)

Table 6.1. The Dialectic Theory of Complexity (Part IV)

- **4th Thesis: The Predictability-Unpredictability Principle**
  - Both predictability and unpredictability have a major role to play in the occurrence of things, so that neither determinism nor indeterminism wins the centuries-old fight.
  - There are events which are predictable, just as there are those which are not. Or what is regarded as unpredictable at one point in time may turn out to be predictable later, and, conversely, what is deemed as predictable may turn out to not be so predictable. Even in predictability, outcomes are subject to uncertainty, the degree of which varies from case to case.
  - For example, in the Newtonian age of classical mechanics, the universe was assumed to be governed by deterministic laws. Yet, with the advance of quantum mechanics in the 20th century, the uncertainty principle mocks Einstein's naivete that God does not play dice with the world.
  - By the same logic, but in the opposite direction, with the discovery of the butterfly effect in chaos theory, it is now understood that there is some emergent order over time even in weather occurrence, so that weather prediction is not next to being impossible as was once thought, although the science of meteorology is far from the state of perfection.
  - The difficulty here is for us to recognize which ones are predictable and which ones are not. Even in predictability, outcomes are subject to uncertainty. This challenge is not trivial, since there are some eminent scholars, like Albert Einstein, who still insisted unto the end of his life, even when confronted with contrary evidences, that "God does not play dice with the universe". (PW 2005)
  - I thus side neither with the determinists nor the indeterminists, and neither with the emergentists nor the reductionists. Both predictability and unpredictability are here to stay.

(continued on next page)

Table 6.1. The Dialectic Theory of Complexity (Part V)

- **5th Thesis: The Post-Human Response**
  - Here is about the response to complexity by the successors of humans, or what I already originally proposed in *FHC* and other books of mine, namely, "post-humans" in the context of human extinction at some distant point of "after-postmodernity".
  - A good case in point here concerns two special forms of post-humans, in what I originally suggested in *FCD* and *FPHC* (and, for that matter, other subsequent books of mine as well) as "floating consciousness" and "hyper-spatial consciousness".
  - The spread of floating consciousness across the cosmos and beyond (without the bio-chemical forms as conventionally understood on earth) in the distant future is a good possibility to illustrate the mastering of complexity in the cosmos in a way that our world has never known.
  - The other one, that is, the emergence of hyper-spatial consciousness in multiple dimensions of space-time that our world has also never experienced, is another good candidate.
  - Yet, the post-humans, even in the most distant future, will still be subject to the constraints as imposed by the first four theses here, in the present context of complexity — or more generally, to the constraints as imposed by the principles in existential dialectics (albeit only at the ontological level, as other levels of analysis are needed too).

Notes: The examples in each thesis are solely illustrative (not exhaustive). The comparison is also relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions.

Sources: A summary of my theory in *FC*

Table 6.2. The Partiality-Totality Principle on Reductionism and Reverse-Reductionism (Part I)

- **The Partiality-Totality Principle**
  - The partiality-totality principle in the ontology of existential dialectics is against the varieties of reductionism and reverse-reductionism (as already worked out in my previous works).

- **Against the Varieties of Reductionism**
  - *Methodological Reductionism*
    - A good instance concerns the debate between different versions of qualitative and quantitative methods (as already analyzed in *FC*, *FHC*, and *FPHC*).
  - *Ontological Reductionism*
    - An excellent example is the debate between emergentism and reductionism in complexity theory and also in psychology (as elaborated in *FPHC*, in the context of both epistemology and ontology, and also *FC*).
  - *Conceptual Reductionism*
    - Some illustrative instances involve myriad dualities like mind vs. body, self vs. world, democracy vs. non-democracy, and the like (as already addressed in *FHC*, *FPHC*, and *BDPD*, for instance).
  - *Theoretical Reductionism*
    - A fascinating case study concerns what I originally called "the foundation fallacy" in *FPHST*, in any attempt to naively understand space-time from the physical perspective as the foundation and, consequently, to dangerously dismiss other perspectives.

(continued on next page)

Table 6.2. The Partiality-Totality Principle on Reductionism and Reverse-Reductionism (Part II)

- **Against the Varieties of Reverse-Reductionism**
  - *Methodological Reverse-Reductionism*
    - There is "anything-goes" mentality in postmodernism (e.g., doing art without praxis, doing art with praxis, and doing art by sublation), as analyzed in Chap. 4 of *FHC*.
  - *Ontological Reverse-Reductionism*
    - There are likewise no privileged ontology, and the door is open for anything in postmodernism (e.g., the equal status of the ontology of Being vs. that of Becoming, as already addressed in Chap. 4 of *FHC* — and also in *FPHC*).
  - *Conceptual Reverse-Reductionism*
    - Any concept of "art" (e.g., fine art, cave art, outsider art, junk art) is deemed acceptable in postmodernism (as already addressed in Chap. 4 of *FHC*).
  - *Theoretical Reverse-Reductionism*
    - There are a plurality of art and literary theories (e.g., New Criticism, Romanticism, Expressionism, Feminist Art Theory) in the postmodern scene, with no one being said to be better than any others (as also addressed in Chap. 4 of *FHC*). In *BNN*, I introduced "the compromise fallacy" as another good example of theoretical reverse-reductionism, in misleadingly treating the genetic and environmental approaches as equally valid.

Sources: A summary of my previous works, especially though not exclusively *FHC*, *FPHC*, *BNN*, *FPHST*, and *FC*.

Table 6.3. Sophisticated Methodological Holism (Part I)

- My methodological holism implies the partiality-totality principle in the ontology of existential dialectics (see the table on the partiality-totality principle for summary), which is against the varieties of (a) reductionism and (b) reverse-reductionism, in relation to (i) concept, (ii) theory, (iii) methodology, and (iv) ontology. (*FC*)

- "[M]y methodological holism here is <u>not</u> opposed to methodological individualism but *includes* it (and, for that matter, other methodologies too)...." (*FPHC*) For this reason (and others too, as summarized hereafter), my version of methodological holism is *sophisticated*—not *vulgar* as sometimes used by inapt scholars using the same term. (*FC*)

- "[M]y methodological holism does not democratically presume that all levels are equally valid, as all levels are not created equal. In other words, in relation to issue X, level A may be more relevant than level B, but in relation to Y, level B can be more relevant than level A instead". (*FPHC*) One excellent example of this vulgar democratic presumption is what I called in *BNN* "the compromise fallacy". (*FC*)

- My methodological holism does not presume that a lower level of analysis is more important than a higher level, solely because the former serves as the foundation for the latter—and vice versa, for that matter. One excellent example of this reductionistic presumption is what I called in *FPHST* "the foundation fallacy". (*FPHST*, *FC*)

- "[M]y methodological holism does not make any a-priori postulation that there must be a definite (and, for that matter, indefinite) number of levels" in any analysis. (*FPHC*) Nor does it dogmatically require that there must be a certain combination of levels of analysis in a given inquiry. (*FC*)

(continued on next page)

Table 6.3. Sophisticated Methodological Holism (Part II)

- "[M]ethodological holism, in my usage, does not assume that all levels…can necessarily be integrated, since methodological holism is not aimed to search for the holy grail of 'an integral theory…' (as is the case for Wilber). In other words, it allows that sometimes some levels may experience irreducible gaps between them, to be understood, at best, as empirical correlations, not as causal relations…." (*FPHC*)

- "[D]ifferent levels may overlap and even interact with each other in a given context (but sometimes may not), and the fact that I even proposed different ways of re-classifying the levels (whenever needed) in *FDC* reinforces this point….The dual danger here is either forcefully making different levels interact when they are just different (or, metaphorically speaking, apples and oranges) or inappropriately ignoring their interactions when some situations instead require them". (*FPHC*)

- "[T]o understand different levels from their own (unique) perspectives (as required by my methodological holism) is not the same as trying to reduce them to a preferred level in the process of learning from other levels. This second kind of multidisciplinary work is not genuine and does no justice to the unique complexities and merits inherent at each level". (*FPHC*)

- "[My] methodological holism walks a fine line between the artificial classification (separation) of levels and the simultaneous incorporation of them, if only for the sake of human scholarly endeavor. It should be reminded that nature does not impose upon itself the academic classification of the levels of analysis as humans have. The enterprise of classification is therefore anthropocentric". (*FPHC*)

(continued on next page)

Table 6.3. Sophisticated Methodological Holism (Part III)

- "[M]y methodological holism advocates neither epistemic subjectivism nor epistemic non-subjectivism (e.g., realism, idealism, and historicism), neither epistemic relativism (e.g., subjectivism, historicism) nor epistemic absolutism (e.g., realism, positivism), neither epistemic reductionism nor epistemic emergencism, and neither epistemic objectivism (e.g., realism, idealism) nor epistemic historicism....Neither does methodological holism, in my usage, accept the false meta-conceptual dichotomy between nominalism and realism....These false dichotomies...are to be transcended. In other words, methodological holism does not fully accept epistemic realism, positivism (a form of epistemic idealism), historicism, subjectivism, and reductionism in epistemology and philosophy of science but learns from the strengths and weaknesses of all of the opposing approaches without siding with any of them...." (*FPHC*)

- Sophisticated methodological holism is subject to the constraints as imposed by the syntax of existential dialectics (e.g., the partiality-totality principle and the predictability-unpredictability principle). Even in predictability, outcomes are subject to uncertainty, the degree of which varies from case to case. (*FC*)

Source: A summary of *Sec. 1.2* in *FPHC*—and also from *BNN*, *FPHST*, and *FC*. See the books for more detail.

Table 6.4. The Conception of Existential Dialectics (Part I)

- **Sets and Elements**
  - *Sets*
    - Ex: the Same
    - Ex: the Others
  - *Elements*
    - Ex: whites in 20th century America (in the set of "the Same")
    - Ex: Iraq during the U.S. invasion in 2003 (in the set of "the Others")

- **Relations, Operations, Functions**
  - *Relations (e.g., "belongs", "equals to", "is greater than")*
    - Ex: symmetric interactions within the Same (or the Others)
    - Ex: asymmetric interactions between the Same and the Others
  - *Operations (e.g., "and", "or", "not", "if…then")*
    - Ex: if the Same oppresses the Others, it will also oppress itself.
    - Ex: the Same is not the Others.
  - *Functions (e.g., goals)*
    - Ex: the Same is hegemonic in relation to the Others.

- **Truth Values**
  - *"1" if True (in Symbolic Logic)*
    - Ex: the proposition that imperial Japan was hegemonic to China during WWII
  - *"0" if False (in Symbolic Logic)*
    - Ex: the proposition that Grenada invaded France in 2003
  - *"1" & "0" if Both True and False (in Dialectic Logic)*
    - Ex: the proposition that the rabbit-duck picture refers to a duck
  - *"~1" & "~0" if Neither True Nor False (or N/A)*
    - Ex: the proposition that God really exists

(continued on next page)

Table 6.4. The Conception of Existential Dialectics (Part II)

- **Axioms, Postulates, Theorems, Principles**
  - *Axioms*
    - Ex: the reflexive axiom — "any quantity is equal to itself"
  - *Postulates*
    - Ex: the SSS postulate — "if the three sides of a triangle are congruent to their corresponding parts, then the triangles are congruent"
  - *Theorems (and Principles) in Existential Dialectics*
    - <u>In Relation to Method</u>
      - The partiality-totality principle
      - The predictability-unpredictability principle
    - <u>In Relation to Process</u>
      - The constancy-change principle
      - The order-chaos principle
    - <u>In Relation to Agency</u>
      - The symmetry-asymmetry principle
    - <u>In Relation to Outcome</u>
      - The regression-progression principle

Notes: The categories and examples in each are solely illustrative (not exhaustive). The comparison is also relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions.

Sources: From Chap. 6 of *BCPC* and also from *FHC*, *FCD*, *FPHC*, *BDPD*, *BNN*, and *FC*

Table 6.5. The Syntax of Existential Dialectics (Part I)

• **In Relation to Method**

– *The Partiality-Totality Principle*
(On the Relationships between Whole and Parts)
- Any inquiry about a phenomenon in the work is to guard against the varieties of reductionism and reverse-reductionism.
- Reductionism and reverse-reductionism can be conceptual, theoretical, methodological, and ontological.
- Sources: Especially from *FC*. See also *FHC*, *FCD*, *FPHC*, *BCPC*, *FPHST*, *BCIV*, *BNN*, and *BWT*.

– *The Predictability-Unpredictability Principle*
(On the Occurrence of Events)
- Both predictability and unpredictability have a major role to play in the occurrence of things, so that neither determinism nor indeterminism wins the centuries-old fight.
- There are events which are predictable, just as there are those which are not. Or what is regarded as unpredictable at one point in time may turn out to be predictable later, and, conversely, what is deemed as predictable may turn out to not be so predictable. Even in predictability, outcomes are subject to uncertainty, the degree of which varies from case to case.
- Sources: Especially from *FC*. See also *FHC*, *FCD*, *FPHC*, *BCPC*, *FPHST*, *BCIV*, *BNN*, and *BWT*.

(continued on next page)

Table 6.5. The Syntax of Existential Dialectics (Part II)

- **In Relation to Process**

  – *The Order-Chaos Principle*
  (On the Process of Change)
    - Both order and chaos are vital in the process of change in the world. The preference for order is biased, since it does not give sufficient attention to the vital role of chaos in the transformation of the world (without somehow reducing it for the understanding of order).
    - The scientific search for order in the world is often a hidden bias in its ontological obsession with order, since chaos is often treated as the "bad" guy, with order as the "good" guy (for the end goal of science).
    - Neither order nor chaos is the final end of the world, and one is not to be treated as the means for the other in the transformation of things. Both are fundamental in their recurrent dialectical interactions with each other over time, without reducing one for the other.
    - Sources: Especially from *FC*. See also *FHC*, *FCD*, *FPHC*, *BCPC*, *FPHST*, *BCIV*, *BNN*, and *BWT*.

  – *The Change-Constancy Principle*
  (On the dynamics of Space-Time)
    - Change occurs over time, although constancy is also allowed.
    - Asymmetry undergoes changes over time, so does symmetry.
    - Old players fade away, and new ones emerges, with ever new causes and ever new forms.
    - Sources: First named in *BCPC*. Especially from *FHC*, *FCD*, and *FPHC*. See also *BDPD*, *FPHST*, *BCIV*, *BNN*, *BWT*, and *FC*.

(continued on next page)

Table 6.5. The Syntax of Existential Dialectics (Part III)

- **In Relation to Agency**
  - *The Symmetry-Asymmetry Principle (On the Relationships among Existents)*
    - The relationships are relatively asymmetric between the Same and the Others but relatively symmetric within the Same (or the Others). There is no asymmetry without symmetry. This is true, even when the Same can be relatively asymmetric towards itself in self-oppression, just as the Others can be likewise towards themselves.
    - The subsequent oppressiveness is dualistic, as much by the Same against the Others and itself, as by the Others against the Same and themselves.
    - Both oppression and self-oppression can be achieved by way of downgrading differences between the Same and the Others and of accentuating them.
    - Sources: From all my books. First named in *BCPC*.
- **In Relation to Outcome**
  - *The Regression-Progression Principle (On the Direction of History)*
    - Neither the cyclical nor the linear views are adequate for explaining many phenomena at all levels.
    - History progresses to more advanced forms, but with a regressive touch. Examples include no freedom without unfreedom, no equality without inequality, and no civilization without barbarity.
    - This is not an inevitable law, but merely a highly likely empirical trend.
    - Sources: From all my books. First named in *BCPC*.

Notes: The features in each principle are solely illustrative (not exhaustive). The comparison is also relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions.

Sources: From Chap. 6 of *BCPC* and also from *FHC*, *FCD*, *FPHC*, *BDPD*, *BNN*, and *FC*

Table 6.6. The Pragmatics of Existential Dialectics (Part I)

- **Direct and Indirect Applications**
  - *Direct*
    - The logic of existential dialectics can shed some theoretical insights on diverse phenomena in the world, and good instances are the pertinent use of the principles of existential dialectics for the theoretical insights on the freedom/unfreedom dialectics, the equality/inequality dialectics, and the wealth/poverty dialectics in my previous works.
    - My latest books like *FPHST* and *BNN* also use the principles to reveal some theoretical insights on the perspectives of space and time (as in *FPHST*) and of nature and nurture (as in *BNN*).
  - *Indirect*
    - The theoretical insights can further be used to reveal other phenomena directly from them (viz., the theoretical insights) and therefore indirectly from the principles themselves. A good instance is the use of the theoretical insights on the freedom/unfreedom and equality/inequality dialectics for the understanding of the civilization/barbarity dialectics.
    - Even in indirect applications, however, a phenomenon under study can still be directly related back to the principles themselves. In the example as cited above, the civilization/barbarity dialectics can be directly related to the principles of existential dialectics without the intermediate role of the freedom/unfreedom and equality/ inequality dialectics.

(continued on next page)

Table 6.6. The Pragmatics of Existential Dialectics (Part II)

- **Multiple Levels of Application**
  - The theoretical insights can be applied to different levels of analysis, even though in a given example, it may refer to one level only. For instance, in the example concerning the freedom/unfreedom dialectics, it can be used at the structural level (e.g., in relation to the theory of cyclical progression of hegemony), but it can be exploited as well for other levels (e.g., the theory of post-capitalism at the institutional level).

Notes: The categories and examples in each are solely illustrative (not exhaustive). The comparison is also relative (not absolute), nor are they mutually exclusive. As generalities, they allow exceptions.
Sources: From Chap. 6 of *BCPC* and also from *FHC*, *FCD*, *FPHC*, *BDPD*, *BNN*, and *FC*. See also *Sec. 1.6* of *FC* for summary.

Bibliography

Abraham, Frederick; Julien Sprott; Olga Mitina; Maureen Osorio; Elvie Dequit & Jeanne Pinili. 2006. "Judgments of Time, Aesthetics, and Complexity as a Function of The Fractal Dimension of Images Formed by Chaotic Attractors". <http://www.blueberry-brain.org/silliman/JEM%20 ms3. htm>.

Alexander, Christopher. 2003. "New Concepts in Complexity Theory: Arising from Studies in the Field of Architecture". <http://www.natureoforder.com/library/scientific-introduction.pdf>.

______.2002. *The Nature of Order : An Essay on the Art of Building and the Nature of the Universe*. Berkeley, CA: Center for Environmental Structure.

Anglin, W.S. 1994. *Mathematics: A Concise history and Philosophy*. NY: Springer-Verlag.

Answers.com (AC). 2006. "Quantum Mechanics, Philosophy and Controversy". <http://www.answers.com/topic/quantum-mechanics-philosophy-and-controversy>.

Arthur, W.B. 1989. "Competing Technologies, Increasing Returns, and Lock-In by Historical Events". *Economics J.*, vol.116: 99.

Avnet, Jeremy. 2000. Senior thesis in mathematics (June) in the University California, Santa Cruz. <http://www.theory.org/complexity/cdpt/html/ node5.html>.

Axelrod, R. 1995. "A model of the Emergence of New Political Actors". *Artificial Societies*. N. Gilbert and R. Conte, eds. London: UCL Press.

Baofu, Peter. 2007. *Beyond the World of Titans, and the Remaking of World Order: Conceiving a Better Way to Understand Empire Building*. Cambridge, England: Cambridge Scholars Publishing, Inc.

______.2006. *Beyond Nature and Nurture: Conceiving a Better Way to Understand Genes and Memes*. Cambridge, England: Cambridge Scholars Publishing, Inc.

______.2006. *The Future of Post-Human Space-Time: Conceiving a Better Way to Understand Space and Time*. New York: Peter Lang Publishing, Inc.

______.2006. *Beyond Civilization to Post-Civilization: Conceiving a Better Model of Life Settlement to Supersede Civilization.* New York: Peter Lang Publishing, Inc.

______.2005. *Beyond Capitalism to Post-Capitalism: Conceiving a Better Model of Wealth Acquisition to Supersede Capitalism.* New York: The Edwin Mellen Press.

______.2004. *The Future of Post-Human Consciousness.* New York: The Edwin Mellen Press.

______.2004a. *Beyond Democracy to Post-Democracy: Conceiving a Better Model of Governance to Supersede Democracy.* 2 volumes. New York: The Edwin Mellen Press.

______.2002. *The Future of Capitalism and Democracy.* Maryland: The University Press of America.

______.2000. *The Future of Human Civilization.* 2 volumes. New York: The Edwin Mellen Press.

Behe, Michael. 2002. "The Challenge of Irreducible Complexity". *Intelligent Design?* (a special report reprinted from *Natural History* magazine). <http://www.actionbioscience.org/evolution/nhmag.html>.

Berlyne, D.E. 1960. *Conflict, Arousal, and Curiosity.* New York: McGraw-Hill.

Birkhoff, G.D. 1933. *Aesthetic Measure.* Cambridge: Harvard University Press.

Biz/ed Newsletter (BN). 2006. "John Maynard Keynes—Theories". <http://www.bized.co.uk/virtual/economy/library/economists/keynesth.htm>.

Bremermann, H. J. 1977. "Transcomputability and Complexity". *The Encyclopaedia of Ignorance.* M. Smith & R. Duncan, eds. London: Routledge and Keagan Paul.

Brody, James, ed. 2000. "Future sense: Complexity Theory and Mobilizing Our Adaptations". <http://www.lssu.edu/oapls/2000conference/abstract/brody1. html>.

Brooks, Daniel & E.O. Wiley. 1986. *Evolution as Entropy: Toward a Unified Theory of Biology.* University of Chicago Press, Chicago.

Gatlin, L.L. 1972. *Information Theory and the Living System.* NY: Columbia University Press.

Carley, K. M.; M. J. Prietula & Zhiang Lin. 1998. "Design Versus Cognition: The Interaction of Agent Cognition and Organizational Design on Organizational Performance". *Journal of Artificial Societies and Social Simulation*, vol. 1, no. 3. <http://www.soc.surrey.ac.uk/JASSS/1/3/4. html>.

Castelfranchi, C.; R. Conte & M. Paolucci. 1998. "Normative Reputation and the Costs of Compliance". *Journal of Artificial Societies and Social Simulation* 1(3): 13. <http://www.soc.surrey.ac.uk/JASSS/1/3/3.html>.

Center for the Study of Complex Systems, the (CSCS). 2006. "Complexity".

Michigan: The University of Michigan.

Clark, Stuart. 2002. "Tough Earth Bug May Be from Mars". *New Scientist* (September). <http://www.newscientist.com/channel/life/evolution/dn2844>.

Colander, David. 1994. *History of Economic Thought*. Boston: Houghton Mifflin Company.

Collier, John. 1986. "Entropy in Evolution". *Biology and Philosophy* 1: 5-24. <http://www.kli.ac.at/theorylab/jdc/papers/entev.pdf>.

Conte, R. & C. Castelfranchi. 1995. "Understanding the Functions of Norms in Social Groups through Simulation". *Artificial Societies*. N. Gilbert and R. Conte, eds. London: UCL Press.

Cosmic Search Magazine (CSM). 1979. "Glossary". Cosmic Quest, Inc. <http://www.bigear.org/vol1no1/glossary.htm>.

Cutler, Robert. 2002. "Complexity Science and Knowledge-Creation in International Relations Theory". *Encyclopedia of Institutional and Infrastructural Resources*, and also *Encyclopedia of Life Support Systems*. Oxford: Eolss Publishers for UNESCO. <http://www.eolss.net>. And also <http://www.robertcutler.org/download/pdf/en02eolx.pdf>.

Davis, M.; Y. Matijasevic & J. Robinson. 1976. "Hilbert's Tenth Problem, Diophantine Equations: Positive Aspects of a Negative Solution". *Proceedings of Symposia in Pure Mathematics*, 28: 323-378.

Davis, R.C. 1936. "An Evaluation and Test of Birkhoff's Aesthetic Measure and Formula". *Journal of General Psychology*, 15: 231-240.

Dean, J.S.; G. J. Gumerman; M. Epstein Joshua; R. L. Axtell; A. C. Swedland; M. T. Parker & S. McCarrol. 1999. "Understanding Anasazi Culture Change through Agent Based Mdeling". *Dynamics in Hman and Pimate societies: Agent Based Modeling of Social and Spatial Processes*. T. A. Kohler and G. J. Gumerman, eds. Oxford University Press.

Dembski, William. 2002. "Intelligence Leaves behind a Characteristic Signature". *Intelligent Design?* (a special report reprinted from *Natural History* magazine). <http://www.actionbioscience.org/evolution/nhmag.html>.

Donald, Merlin. 1991. *The Origin of the Modern Mind*. Cambridge, Mass., Havard University Press.

Doran, J. E. 1977. "Foreknowledge in Artificial Societies". *Simulating Social Phenomena*. R. Conte, R. Hegselmann, and P. Tierna, eds. Also, lecture notes in *Economics and Mathematical Systems* 456. Springer: Berlin.

Dreyfus, H. 2000. "Telepistemology: Descartes' Last Stand". *The Robot in the Garden*. K. Goldberg, ed. MA: MIT Press.

______.1990. "What is Moral Maturity? A Phenomenological Account of the Development of Ethical Expertise". <http://ist-socrates.berkeley.edu/~hdreyfus/rtf/Moral_Maturity_8_90.rtf>.

Economist, the. 2006. "Computing the Future" (March 23).

<http://www.economist.com/science/displaystory.cfm?story_id=5655067>.

Eidelson, Benjamin M. & Ian Lustick. 2004. "VIR-POX: An Agent-Based Analysis of Smallpox Preparedness and Response Policy". *Journal of Artificial Societies and Social Simulation*, vol. 7. <http://jasss.soc.surrey.ac.uk/7/3/6.html>.

Elias, Norbert. 1998. *The Norbert Elias Reader: A Biographical Selection*, J. Goudsblom, ed. Oxford, UK: Blackwell.

Encyclopedia of Life Support Systems (EOLSS). 2006. "Knowledge Management, Organizational Intelligence and Learning, and Complexity". UNESCO. <http://www.utdallas.edu/dept/socsci/Fourth.htm>.

Eysenck, H. J. 1941. "The Empirical Determination of an Aesthetic Formula". *Psychological Review*, 48: 83-92.

Fama, Eugene. 1965. "The Behavior of Stock Market Prices". *Journal of Business*. Chicago, IL: The University of Chicago Press.

Fechner, G.T. 1876. *Vorschule der Äesthtik*. Leipzig: Breitkopf & Härtel.

Flentge, Felix; Daniel Polani & Thomas Uthmann. 2001. "Modelling the Emergence of Possession Norms using Memes". *Journal of Artificial Societies and Social Simulation*, vol. 4, no. 4. <http://www.soc.surrey.ac.uk/JASSS/4/4/3.html>

Freeman, W.J. 1992. "Tutorial on Neurobiology: From Single Neurons to Brain Chaos". *International Journal of Bifurcation and Chaos* 2(3), 451-482.

Ghorai, S. 2003. "Rayleigh-Benard Convection". <http://home.iitk.ac.in/%7Esghorai/NOTES/benard/benard.html>.

Gilbert, Nigel. 2004. "Agent-Based Social Simulation: Dealing with Complexity" (December 18). <http://www.econ.iastate.edu/tesfatsi/ABM.DealingWithComplexity.Gilbert.pdf>.

_____. 1995. "Emergence in Social Simulation". *Artificial Societies: The Computer Simulation of Social Life*. N. Gilbert and R. Conte, eds. London: UCL Press.

Gimblett, H. R.; R. M. Itami & M. Richards. 2002. "Simulating Wildland Recreation Use and Conflicting Spatial Interactions using Rule-Driven Intelligent Agents". *Integrating GIS and Agent Based Modeling Techniques for Understanding Social and Ecological Processes*. H. R Gimblett, eds. England: Oxford University Press.

Gleick, James. 1988. *Chaos : Making a New Science*. NY: Penguin.

Gödel, K. 1931. *On Formally Undecidable Propositions of Principia Mathematica and Related Systems*. New York: Basic Books.

Goldenfeld, Nigel & Leo P. Kadanoff. 1999. "Simple Lessons from Complexity". *Science* 284: 87-89. <http://guava.physics.uiuc.edu/~nigel/articles/complexity.html>.

Graves, E.M. 1951. *The Art of Color and Design*. New York: McGraw-Hill.

Green, David. 1994. “Connectivity and the Evolution of Biological Systems”. *J. Biological Systems*, 2(1), 91-103.

Green, David & David Newth. 2001. “Towards a Theory of Everything? – Grand Challenges in Complexity and Informatics”. *Complexity International*: volume 08. <http://www.complexity.org.au/ci/vol08/green05/green05.pdf>.

Grossman, W. 2004. “New Tack Wins Prisoner's Dilemma”. <http://www.wired.com/news/culture/0,1284,65317,00.html>.

Hales, David. 2002. “Group Reputation Supports Beneficent Norms”. *Journal of Artificial Societies and Social* Simulation, vol. 5, no. 4. <http://jasss.soc.surrey.ac.uk/5/4/4.html>.

Hayek, Friedrich A. 1967. “The Theory of Complex Phenomena”. *Studies in Philosophy, Politics, and Economics*. London: Routledge & Kegan Paul, 22-42.

______.1948. *Individualism and Economic Order*. Chicago: University of Chicago Press.

Hazen, Robert. 2001. “Science, Religion, and the Origin of Life”. AAAS Lecture Series. Washington, DC (September 13).

Hilbert, D. 1922. “Neubegründung der Mathematik. Erste Mitteilung”, *Hamburger Mathematische Seminarabhandlungen* (“The New Grounding of Mathematics. First Report”). In *From Hilbert to Brouwer. The Debate on the Foundations of Mathematics in the 1920s*, P. Mancosu, tr. (Oxford, UK: Oxford University Press, 1998).

Horgan, John. 1995. “From Complexity to Perplexity”, *Scientific American*, 272(6), 104-109.

Hume, David. 1967. *A Treatise of Human Nature*. England: Oxford University Press.

Isaak, Mark. 1997. “Five Major Misconceptions about Evolution”. *The TalkOrigins Archive: Exploring the Creation/Evolution Controversy*. <http://www.talkorigins.org/faqs/faq-misconceptions.html>.

Johnson, Steven. 2002. *Emergence: The Connected Lives of Ants, Brains, cities, and Software*. New York: Simon & Schuster.

Kleene, Stephen C. 1991. *Introduction to Meta-Mathematics*. Amsterdam NY: North-Holland Pub. Co.

Kuhn, T.S. 1962. *The Structure of Scientific Revolutions*. Chicago, Ill., USA: University of Chicago Press.

Lakatos, Imre. 1970. “Falsification and the Methodology of Scientific Research Programs”. *Criticism and the Growth of Knowledge*, I. Lakatos and A. Musgrave, eds. Cambridge, UK: Cambridge University Press.

Labini, Francesco & Luciano Pietronero. 2001. “Complexity in Cosmology: Statistical Properties of Galaxy Large Scale Structures”. <http://arxiv.org/PS_cache/astro-ph/pdf/0102/0102320.pdf>.

Langton, C. G. 1990. “Computation at the Edge of Chaos: Phase Transition and Emergent Computation”. *Physica D*, 42(1-3):12-37.

Latané, B. & A. Nowak. 1994. “Simulating the Emergence of Social Order from Individual Behaviour”. *Simulating Societies: The Computer Simulation of Social Phenomena*. N. Gilbert and J. Doran, eds. London: UCL Press.

Lavoie, Don. 1989. “Economic Chaos or Spontaneous Order? Implications for Political Economy of the New View of Science”, *Cato Journal*, 8, 613-635.

Leach, Mark. 2006. “Chemical Systems Prone to Complexity”. *The Chemogenesis Web Book*. <http://www.meta-synthesis.com/ webbook/ 24_complexity/complexity3.html#IE>.

Lin, Li-Hung, Pei-Ling Wang, Douglas Rumble, Johanna Lippmann-Pipke, Erik Boice, Lisa M. Pratt, Barbara Sherwood Lollar, Eoin L. Brodie, Terry C. Hazen, Gary L. Andersen, Todd Z. DeSantis, Duane P. Moser, Dave Kershaw, T. C. Onstott. 2006. “Long-Term Sustainability of a High-Energy, Low-Diversity Crustal Biome”. *Science* 314: 479-482. <http://www.sciencemag.org/cgi/content/abstract/314/5798/479>.

Lo, Andrew & A. Craig MacKinlay. 1999. *A Non-random Walk Down Wall St*. NJ: Princeton University Press.

Logan, Robert. 2006. “The Extended Mind: Understanding Language and Thought in Terms of Complexity and Chaos Theory”. University of Toronto. <http://www.upscale.utoronto.ca/GeneralInterest/Logan/ Extended/Extended.html>.

______.1995. *The Fifth Language*. Toronto: Stoddart.

Lorenz, Edward N. 1993. *The Essence of Chaos*. Seattle: University of Washington Press.

Lucas, J. R. 1961 . “Minds, Machines and Gödel”. *Philosophy* 36:120-124.

Machta, J. 2006. “Complexity, Parallel Computation and Statistical Physics”. A paper for the conference on the “Understanding Complex Systems” at the University of Illinois–Urbana Champaign on May 2005. <http://www-unix.oit.umass.edu/~machta/Complexity11_5,46(2006).pdf>.

Malkiel, Burton. 1973. *A Random Walk Down Wall Street*. NJ: Princeton University Press.

Mancosu, P. 1998. *From Hilbert to Brouwer. The Debate on the Foundations of Mathematics in the 1920s*. Oxford, UK: Oxford University Press.

May, R.M. 1973. *Stability and Complexity in Model Ecosystems*. NJ: Princeton University Press.

Mejias, Ulises Ali. 2005. “Is Morality an Emergent Behavior?” <http://ideant.typepad.com/ideant/2005/01/is_morality_an_.html>.

Merriam-Webster’s Collegiate Dictionary Online (MWD). 2006. “Parsec”. <http://www.m-w.com/dictionary/parsecs>.

Moss, Scott. 1998. “Critical Incident Management: An Empirically Derived Computational Model”. *Journal of Artificial Societies and Social*

Simulation, vol. 1, no. 4. <http://www.soc.surrey.ac.uk/JASSS/1/4/1. html>.

Pennock, Robert. 2002. "Mystery Science Theater: The Case of the Secret Agent". *Intelligent Design?* (a special report reprinted from *Natural History* magazine). <http://www.actionbioscience.org/evolution/nhmag.html>.

Penrose, R. 1994. *Shadows of the Mind*. Oxford: Oxford University Press.

______.1989. *The Emperor's New Mind: Concerning Computers, Minds and the Laws of Physics*. Oxford: Oxford University Press.

Perrow, Charles. 1984. *Normal Accidents: Living with High-Risk Technologies*. NY: Basic Books.

Philosophy Professor (PP). 2006. "Indeterminism". <http://www.philosophy professor.com/philosophies/indeterminism.php>.

PhysicsWeb (PW). 2005. "Does God Play Dice?" <http://physicsweb.org/articles/world/18/12/2/1>.

Popper, K.R. 1959. *The Logic of Scientific Discovery*. London, UK: Routledge.

Pyka, Andreas; N. Gilbert & Petra Ahrweiler. 2001. "Innovation Networks—A Simulation Approach". *Journal of Artificial Societies and Social* Simulation, vol. 4, no. 3. <http://www.soc.surrey.ac.uk/JASSS/4/3/8. html>.

Rae, Greg. 2006. "Chaos Theory: A Brief Introduction". <http://www.imho.com/grae/chaos/chaos.html>.

Rosen, Robert. 2006. "Rosennean Complexity". *Complexity and Life*. <http://www.panmere.com/rosen/faq_complex1.htm#sec8>.

Rosser, J. Barkley, ed. 2003. *Complexity in Economics*. <http://cob.jmu.edu/ rosserjb/COMPLEXITY%20IN%20ECONOMICS.doc>.

Saam, Nicole J. & Andreas Harrer. 1999. "Simulating Norms, Social Inequality, and Functional Change in Artificial Societies". *Journal of Artificial Societies and Social Simulation*, vol. 2, no. 1. <http://www.soc.surrey.ac.uk/JASSS /2/1/2.html>.

Salisbury, David. 1999. "Inflation: Bad for the Economy, but a Key to the Origin of the Universe". *Stanford Report*. <http://news-service.stanford.edu/ news/1999/january27/inflate127.html>.

Scha, Remko & Rens Rod. 1993. "Computational Esthetics". Originally published (in Dutch) in *Informatie en Informatiebeleid* 11, 1: 54-63. <http://iaaa.nl/rs/compestE.html>.

Schelling, T. C. 1971. "Dynamic Models of Segregation". *Journal of Mathematical Sociology*, 1: 143-186.

Scott, W.Richard. 2002. *Organizations: Rational, Natural, and Open Systems*. New Jersey: Prentice Hall.

Shakespeare, William. 1995. *Romeo and Juliet*. Intr. Cedric Watts. London: Prentice Hall.

Shlain, Leonard. 1991. *Art and Physics: Parallel Visions in Space,Time, and*

Light. New York: William Morrow and Co., Inc.

Sokal, Alan & Jean Bricmont. 1998. *Fashionable Nonsense*. NY: Picador.

Staller, Alexander & Paolo Petta. 2001. "Introducing Emotions into the Computational Study of Social Norms: A First Evaluation". *Journal of Artificial Societies and Social Simulation*, vol. 4, no. 1. <http://www.soc.surrey.ac.uk/JASSS/4/1/2.html>.

Steeman, Fedor. 2006. "The 10 Main Arguments against Creationism". <http://www.geocities.com/fedor_steeman/10main.html>.

Steiger, Frank. 1997. "The Second Law of Thermodynamics, Evolution, and Probability". *The TalkOrigins Archive: Exploring the Creation/Evolution Controversy*. <http://www.talkorigins.org/faqs/thermo/probability.html>.

Stewart, Ian. 1989. *Does God Play Dice? The Mathematics of Chaos*. NY: Blackwell.

Teixeira, Joao. 1998. "Computational Complexity and Philosophical Dualism". *Philosophy and Cognitive Science*. Paper originally presented at the Twentieth World Congress of Philosophy in Boston. <http://www.bu.edu/wcp/Papers/Cogn/CognTeix.htm>.

Troitzsch, K. G. & N. Gilbert. 2005. *Simulation for the Social Scientist*. Milton Keynes: Open University Press.

Turing, A. M. 1939. "Systems of Logic Based on Ordinals". *Proceedings of the London Mathematical Society*, 45:161-228.

______.1936. "On Computable Numbers, with an Application to the Entscheidungsproblem". *Proceedings of the London Mathematical Society*, 42:230-65.

Virtual Magic (VM). 2006. "John Milton Cage". <http://virtualmagic.blogspot.com/2006/09/john-cage.html>.

Wikipedia (WK). 2007. "Foundations of Mathematics". <http://en.wikipedia.org/wiki/Foundations_of_mathematics>.

______.2006. "Complexity". <http://en.wikipedia.org/wiki/ Complexity>.

______.2006a. "Computational Complexity Theory". <http://en.wikipedia.org/wiki/Computational_complexity_theory>.

______.2006b. "Indeterminism". <http://en.wikipedia.org/wiki/ Indeterminism>.

______.2006c. "Self-Organization". <http://en.wikipedia.org/wiki/Self_organization>.

______.2006d. "Positive Feedback". <http://en.wikipedia.org/wiki/Positive_feedback>.

______.2006e. "Randomness". <http://en.wikipedia.org/wiki/Randomness>.

______.2006f. "Arbitrary". <http://en.wikipedia.org/wiki/Arbitrary>.

______.2006g. "Emergence". <http://en.wikipedia.org/wiki/Emergence>.

______.2006h. "Uncertainty Principle". <http://en.wikipedia.org/wiki/Uncertainty_principle>.

______.2006i. “Stereoisomerism”. <http://en.wikipedia.org/wiki/Stereoisomer ism>.
______.2006j. “Qunatum Mechanics”. <http://en.wikipedia.org/wiki/ Quantum _mechanics>.
______.2006k. “Uncertainty Principle”. <http://en.wikipedia.org/wiki/ Uncertainty_principle>.
______.2006l. “Origin of Life”. <http://en.wikipedia.org/wiki/Origin_of_life>.
______.2006m. “Autocatalytic Set”. <http://en.wikipedia.org/wiki/ Autocatalytic_set>.
______.2006n. “Connectionism”. <http://en.wikipedia.org/wiki/Connec tionism>.
______.2006o. “Dynamic Systems”. <http://en.wikipedia.org/wiki/Dynamic_ systems>.
______.2006p. “Chaos Theory”. <http://en.wikipedia.org/wiki/Chaos_theory>.
______.2006q. “Complexity Theory and Organizations”. <http://en.wikipedia. org/wiki/Complexity_theory_of_organizational_structure>.
______.2006r. “System Accident”. <http://en.wikipedia.org/wiki/Normal_ accident>.
______.2006s. “Garbage Can Model”. <http://en.wikipedia.org/wiki/ Garbage_ Can_Model>.
______.2006t. “A New Kind of Science”. <http://en.wikipedia.org/ wiki/ A_New_Kind_of_Science>.
______.2006u. “Determinism”. <http://en.wikipedia.org/ wiki/Determinism>.
______.2006v. “Free Will”. <http://en.wikipedia.org/wiki/ Free_will>.
______.2006w. “Fractals”. <http://en.wikipedia.org/wiki/ Fractals>.
______.2006x. “Parallel Processing”. <http://en.wikipedia.org/wiki/ Parallel_ processing>.
______.2006y. “Turing Complete”. <http://en.wikipedia.org/wiki/Turing_ complete>.
______.2006z. “Rule 110 Cellular Automaton”. <http://en.wikipedia.org/ wiki/Rule_110_cellular_automaton>.
______.2006aa. “Random Walk Hypothesis”. <http://en.wikipedia.org/ wiki/ Random_walk_hypothesis>.
______.2006bb. “Efficient Market Hypothesis”. <http://en.wikipedia.org/ wiki/ Efficient_market_hypothesis>.
______.2006cc. “Gödel’s Incompleteness Theorems”. <http://en.wikipedia. org/wiki/Incompleteness_theorem>.
______.2006dd. “Linguistics”. <http://en.wikipedia.org/ wiki/Linguistics>.
______.2006ee. “Falsifiability”. <http://en.wikipedia.org/wiki/ Falsifiability>.
______.2006ff. “Verificationism”. <http://en.wikipedia.org/wiki/ Verifica tionism>.
______.2006gg. “Evolution”. <http://en.wikipedia.org/ wiki/Evolution>.

______.2006hh. “Metereology”. <http://en.wikipedia.org/ wiki/Metereology>.

Wolfram, Stephen. 2002. *A New Kind of Science*. Champaign, IL : Wolfram Media.

Woo, Joseph. 1995. “Obstetric Ultrasound: A Comprehensive Guide to Ultrasound Scans”. *Kinderstart.com.* <http://www.kinderstart.com/ frame_for_links.php?redirect =http://www.ob-ultrasound.net>.

Yahoo! News (YN). 2007. “China Facing Major Gender Imbalance”. (Jan. 12). <http://news.yahoo.com/s/ap/20070112/ap_on_re_as/china_gender_im balance>.

Younger, Stephen. 2004. “Reciprocity, Normative Reputation, and the Development of Mutual Obligation in Gift-Giving Societies”. *Journal of Artificial Societies and Social Simulation*, vol. 7, no. 1. <http://jasss.soc.surrey.ac.uk/7/1/5.html>.

Index

•A•

•B•

•C•

•D•

•E•

•F•

•G•

•H•

•J•

•K•

•L•

•M•

•N•

•O•

•P•

•Q•

•R•

•S•

•T•

•U•

•V•

W•

•X•

•Y•

•Z•