Rupert Riedl

# Structures of Complexity

## A Morphology of Recognition and Explanation

Springer

# Structures of Complexity

Rupert Riedl

# Structures of Complexity

## A Morphology of Recognition and Explanation

Springer

club of vienna

WIEN KULTUR

Rupert Riedl (Deceased)
Konrad Lorenz Institute for
Evolution and Cognition Research
Altenberg, Austria

Translated by Michael Stachowitsch, University of Vienna, Austria

This translation was funded by the *Vienna Municipal Department 7* and the *Club of Vienna*

ISBN 978-3-030-13063-3 ISBN 978-3-030-13064-0 (eBook)
https://doi.org/10.1007/978-3-030-13064-0



This Springer imprint is published by the registered company Springer Nature Switzerland AG.
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

# Foreword 1

Today, humankind faces challenges that go far beyond the uncertainties and quirks of nature, to which we have had ample time to adapt. The problems we now face arise from the interplay between two sources of complexity, that of the natural system and that of the technical world we ourselves have created. "We are intervening in a world that we have not yet understood" was one of Rupert Riedl's most common pronouncements. Importantly, the cognitive pathway runs in the counter-direction to the developmental pathway. Riedl's insights and methodological approaches push the traditional boundaries of science and are widely applicable. This is because the journey along the two pathways in pursuit of underlying causes means tackling both the "hierarchy of disciplines" and the evolutionary hierarchies. No solution can be reached without illuminating the causes behind the developmental pathway.

Responsible, scientifically founded advice to decision-makers requires going beyond the easily recognizable symptoms to understanding the causes behind the problems we face. Exponential growth as a fundamental principle has accelerated every aspect of human endeavor, and science itself has helped fuel the process. This growth has diverted funds and reduced the time available for dealing with underlying processes. We spend too much time plausibly describing visible phenomena and deriving short-sighted measures. This is a dead end. We need to query the causes behind the individual disciplines and promote interdisciplinarity to better shape our world. Technology has enabled us to transcend our innate sensory (spatial and temporal) perception, has abetted ever-narrower specialization, and has enticed us to intervene at all levels. Nonetheless, short-circuiting the "polluter pays" principle, i.e., eliminating the feedback of an action on the perpetrator, as new technologies or the media tend to do, scuttles vital learning processes. A case in point is the obligatory interaction between material and formal causes of adjoining tiers in the hierarchy of complexity, or the purposes and drives that traverse all tiers. In the technical disciplines, the two internal (formal and material) causes apparently suffice for most researchers. The purposes and drives, in contrast, are left to other disciplines despite their effects and feedbacks on every human intervention. This shifts an ethics of responsibility into one dominated by opinion—a recipe for responsibility-free conduct. Today's dominant corporate logic demonstrates that the structure of thought has been fully translated into real structures of action, circumventing the barriers imposed by democratic institutions.

Evolution has equipped us astoundingly well to survive in the complex world in which we arose, making us the dominant higher-developed species on the planet. New methodologies and technologies have boosted our capacity to realize ideas that far exceed direct, intuitive perception. The unforeseen repercussions have hit us unprepared. We have replaced sensible observation of changes in the real world with the virtual reality modeled in subdisciplines. Neglecting "external effects," a routine approach in economics, is foreign to evolution and leads to "collateral damage" in the technical applications by some sciences. These threaten the existence of human civilization. Fragments of Rupert Riedl's thoughts and insights have increasingly cropped up in publications, conferences and symposia dealing with the development of new technologies and with our efforts to understand them. The present book compiles this vision in condensed form. As in his other highly recommended works, this volume is excellently illustrated: as a biologist, Rupert understood that comprehending complex structures is best mediated by relying on our visual capabilities.

This translation was prompted by internationally active colleagues from a range of disciplines who have recognized that the fundamental perspectives and insights outlined in this book are widely unknown in today's English-speaking community, with its quantitative bent. International collaborations in various sectors of technology and economics have also increasingly underlined the need for an English translation of *Structures of Complexity*.

Thanks to funding from the Vienna Municipal Department 7, the Club of Vienna was able to support the translation into English. Special thanks go to the translator, Dr. Michael Stachowitsch, a student of Rupert Riedl's, and to his daughter, Dr. Barbara Schweder, who provided editorial input. We are also grateful to Rupert's family, who consented to and supported publication, and to Springer for taking on this project.

January 2019

Hermann Knoflacher
President Club of Vienna, Gugging
Vienna, Austria

# Foreword 2

When I first met Rupert Riedl 33 years ago through my wife, he was already a renowned scientist. Back then, he gave us a copy of his book *The Strategy of Genesis* with the dedication "fondly remembering our computer discussions." As a software engineer and freshly minted computer artist, I was convinced that evolution and number structures were deeply intertwined. I was truly impressed that a zoologist knew so much about highly abstract phenomena of patterns.

Fifteen years later, Rupert, who in the meantime had become a friend, gave me a copy of his latest book *Strukturen der Komplexität* (*Structures of Complexity*). It changed my life. Up until then, I, like many others, was certain that the future of science lay in ever-further specialization. Rupert, however, felt that morphology had unjustifiably slipped from the focus of scientific endeavor. The developments of the past 10 years have brilliantly proven him correct. Even the insight that entropy and the monetary system are tightly interrelated is already addressed in that volume.

It saddens my heart that Rupert Riedl's important contribution to the history of information processing and to the development of computer art—along with modern concepts such as digitalization, the Internet of Things, or crypto-economy—is so poorly recognized. One potential explanation is that his most important contribution has only now been translated into English.

I am very proud to have been able to contribute to making the translation and new edition of such essential reading for the twenty-first century a reality.

February 2019

Peter Kotauczek
Burg Hartenstein
Weinzierl am Walde, Austria

# Preface

Some people are naturally attracted to complex phenomena. They simply creep up on us in our daily lives or we actively seek them out. That must be what happened to me. This was no doubt promoted by my "right brain hemisphere preference," the pleasure afforded by a synoptic worldview, and the artistic world of my sculptor father—aided and abetted by the tenets of morphology and by my teachers *Ludwig von Bertalanffy* and *Konrad Lorenz*.

*Where is my experience anchored?* I started out with the systematics and microscopic anatomy of marine invertebrates and then published the *Fauna und Flora der Adria* (*Fauna and Flora of the Adriatic Sea*), later expanded to encompass the Mediterranean, followed by *Biologie der Meereshöhlen* (*Biology of Marine Caves*) and, finally, a book examining the Mediterranean as an ecosystem (*Gärten des Poseidon*, *Gardens of Poseidon*). Each endeavor sought to interlink thousands of species. The complex interrelationships I recognized in those efforts led to my books *A Systems Theory of Evolution* (*Systemtheorie der Evolution*) and *The Strategy of Genesis* (*Strategie der Genesis*). I soon recognized that the thought processes behind grasping complexity—involving differentiated and recursive causality—were poorly understood. The impression was that we were simply projecting our thought patterns onto natural patterns of order. This prompted me to develop a "naturalized theory" of cognitive processes in a series of further volumes, whose contents contribute to the discussions in this book.

*What are the new aspects?* I admittedly rely here on some of the above experience and have updated selected illustrations with proven didactic merit. Basically, however, I present all the new knowledge that has enriched science as a whole, thanks to the integration of anatomy, systematics, evolutionary theory, and epistemology.

This approach builds on juxtaposing the terms rational and ratiomorphic, cognition and explanation, and systems of thought and conceptual structures, as well as on distinguishing between structural and class hierarchies. Doing justice to the structures of complexity benefits from perceiving these phenomena in the form of twin pyramids comprising standard building blocks and individual components. If we wish to adapt to complex systems, we must recognize the cognitive dualisms behind our understanding of causes and effects, and we need to perceive and differentiate the suggestions triggered by observation and explanation. This is because the explanatory pathways run counter to the cognitive pathways, with both recapitulating the developmental pathway of complexity in this world.

This book's perspective is rooted in biology and is complementary to the treatments proffered by physicists and mathematicians. For one, I come from biology. Equally important, modern biologists are instilled with the complexity of their discipline (2 million species and 500,000 system categories multiplied by dozens of specific characters)—many millions of individual facts making up a single, enormous, interrelated constellation. This complexity generates a greater body of experience than other scientific disciplines. Moreover, we biologists have accessed the cognitive processes defining our species in the framework of "evolutionary epistemology"—and have learned to relate these to external reality.

*My aspiration* is to be able to apply this body of gained experience to any complex system. I have time and time again had the opportunity to investigate this issue under a variety of perspectives. This is honed with an appreciation for the difficulties in conveying this message based on the reception given to my books and on classroom feedback. Our makeup, our faculties, are unprepared for unraveling complex matters, and this inability is reflected up into the structure of our universities. Importantly, we ourselves are complex: we live based entirely on complexity and our survival depends on it. This warrants an attempt at providing an overview and summary.

Altenberg, Austria
March 2000

Rupert Riedl

# Contents

# Chapter 1
# The Issues Tackled Here: An Introduction

Our worldview has been negligently compartmentalized and simplified. At the same time, we have allowed the world around us to become so complex that we are increasingly less able to comprehend it (Riedl and Delpos 1996a). This is abetted and formalized by the largely analytical approaches of the neatly subdivided disciplines in the natural sciences. It is also promoted by human society, which rewards those who most skillfully intervene in nature. The result is, sad to say, that we tend to confuse graspable circumstances with the real world itself.

The definitional nature of our logic and languages may well have set the stage for this. The rationalistic bent of modern culture has further channeled our thought processes into simplifications, adding insult to injury.

## 1.1 The Topic at Hand

The above situation requires delving into the issue of complexity and focusing on holistic perspectives, on interdisciplinarity and on synoptic approaches. Although these concepts have become modern catchwords, much still remains to be done to remove the many hurdles facing this new movement.

This calls for (Sect. 1.1.1) reviewing the research landscape, (Sect. 1.1.2) discerning the features of complexity, and finally (Sect. 1.1.3) outlining the importance of focusing on structure.

### *1.1.1 Research into Complexity Today*

Complexity was a staple for classical biologists, in contrast to the 'exact sciences'. In physics, the traditional approach was to circumvent the complexity of this world and focus on the remnants that proved to be mathematically representable. The



R. Riedl, *Structures of Complexity*,
https://doi.org/10.1007/978-3-030-13064-0_1

successes of this reductive method are legendary and led to the assumption of 'immutable laws', to the expectation that every natural phenomenon could be reduced to such laws. This stylized the methodology applied by physics into a fundamental paradigm for all natural sciences, reducing biologists to narrators of ephemeral stories. It also further marginalized the humanities.

The first step is to compare the position of (a) biology with (b) the shift in focus of inorganic scientists to complexity, (c) their current situation and (d) the strategy underlying my approach.

(a) *Biologists* have increasingly endeavored to fill the divisive trenches. One motivation was that biology itself faced the prospect of being cleaved into a causalistic physiology and a 'hermeneutic' morphology. This was accompanied by the recognition that this artificial methodological divide was the very site at which inorganic scientists and scholars in the humanities could initiate a dialogue (Riedl 1985).

(b) Importantly, however, the *inorganic sciences* are also undergoing change. This is prompted by their successes in tackling biological questions and by the attendant necessity of addressing complexity. The exact time point of the shift is difficult to determine—perhaps as far back as Schrödinger's 'What is Life' (1957).

The result, however, is indisputable. Irreversibility—the historicity of the complex world—was discovered, and the inorganic realm was no exception. We recognized the phase transitions in every form of evolution and the limits of predictability. We acknowledged 'inner' conditionalities, ordering parameters and the buildup of order by exporting entropy. The resulting insight is that complex systems cannot be entirely reduced to their constituent components. All these concepts converge in the paradigm of biology and are treated here.

The available literature is voluminous. New disciplines have arisen—non-equilibrium thermodynamics, synergetics, chaos research and fractals to name a few—each yielding its own series of monographs. This heroic movement, which transcends classical physics, has made headway both on the scientific and popular level. Ebeling and Feistel (1994), Gell-Mann (1994), Lewin (1993), Nicolis and Prigogine (1987) or Ebeling et al. (1998) are examples. For a key symposium, see Schweitzer (1997).

(c) Nonetheless, the overall *situation* is perceived as being unsatisfactory. The study of complexity is said to be 'in a crisis' (Horgan 1995). Herbert Simon felt that the potential of mathematical solutions might be overestimated. Insufficient consideration is being given to emergence phenomena in the phase transitions. Will we fail to overcome reductionism after all, expecting to ultimately be able to reconstruct complex entities based on their components? Many of these concepts crop up in the following chapters.

Of course, every attempt to overcome classical physics is again anchored in physics itself. Which is all very legitimate. Unsurprisingly, the exceptional insights afforded by modern molecular research have spawned the rationale that we must continue to work from that perspective. In my opinion, surmounting this paradigm calls for an epistemological shift and for refocusing on those paradigms that have already proven themselves in biology.

The necessity for pursuing the epistemological approach created a movement whose intellectual history is outlined by Mainzer (1994). That effort still predates a 'naturalized epistemology', foremost 'evolutionary epistemology' as advocated by Lorenz, Mohr, Oeser, Riedl, Vollmer and Wuketits. The latter approach tackles the origins of human reason and examines the inherent difficulties that history has imposed on arriving at an understanding of complexity. This is the point of departure for this book.

(d) With regard to *the paradigms*, the paradigm of physics is not the cornerstone for my approach. While the insights provided by physics cannot be contradicted, they do require a new superstructure. My arguments are founded in the paradigm of biology. Why? Because, as I will outline in detail, biology is the hub that can re-link the inorganic realm with the humanities and social sciences. The answer lies in reconciling cause-and-effect physiology with hermeneutically operating morphology.

Importantly, any shift in perspective must build on a new set of tools. A new method and terminology along with a new form of portrayal are required to do justice to the topic. As the term 'synoptic' implies, observation and perception are central. The task involves attaining a 'combinational overview', something we are quite well equipped to do (Riedl 1987a). This calls for 'pictorial' abstraction because such depictions—both of natural forms and cognitive forms—provide immediate and convincing insights. Synthesizing the overarching principles then establishes the gateway to the structures of complexity.

The task is twofold: it involves investigating the structures of extra-subjective reality and, equally importantly, the structures of our thought patterns and their history. Our forms of thought (at least those vital for survival) were shaped by correctly processing the structures in our surroundings. Where the two match, they often serve us better than we think. Where they prove to be overtaxed—something we like to ignore—they become potentially treacherous stumbling blocks. This describes the issues tackled here.

### *1.1.2 Complexity: Its Characteristics and Its Meaning*

We refer to structural and functional interrelationships as being complex and group them according the gradual permutations of certain features, be they natural objects, artefacts, notional forms or thought processes. They can be complicated, but complication is not their defining feature.

This calls for (a) formulating a definition of complexity and then examining (b) its manifestations, (c) its significance and (d) how to approach it technically.

(a) Sharply honing a definition of complexity would be misleading. This is because complexity is a wide-ranging and manifold condition in our world, and also consistently polymorphic. Arriving at an adequate definition would require incorporating a lengthy series of features.

The better approach is therefore to (a1) distill its general features, which also encompass other states, and to (a2) define the series of specific features characterizing all gradients.

- (a1) *Complexity contains forms of order*. This means complexity is variously removed from physical equilibrium, from thermodynamic chaos (the equal distribution of matter and its temperatures). Creating and maintaining order must comply with the conditions governing open systems: they are traversed by matter and energy and achieve their ordered structure by exporting entropy. They can also be referred to as dissipative (German: *zerstreuende*) systems because, at the very least, they release heat. Order in complex systems can broadly be understood as law multiplied times application (LxA; details in Riedl 1975). This is equally valid for a local cultural ordinance (complex law times rare application) as it is for the universal law of gravity (simple law times countless applications).

  At the same time, every hot object emits heat. Although every piping system releases frictional heat, it cannot be said to be complex even though material and energy flow through it. Crystallization also releases heat and leads to a high degree of order without fully satisfying the conditions of complexity.
- (a2) Complexity contains gradients of features. Gradients because the features themselves can be expressed in highly differentiated form. Experts refer to system properties or, more broadly, to the product of self-organization processes (versus minimal 'outside organization'). Three groups are differentiated here (i–iii):

  (i) *Historicity* is a main feature. This refers to historical uniqueness and encompasses three sub-characters: *irreversibility*, *phase transitions* and *emergences*. The first means that the developmental processes can neither be traced back along the same path nor be repeated. Rather, they have gone through phase transitions, each of which in itself is unique and typically neither accessible nor repeatable. In fact, these transitions lead to the emergence of new features that are not contained even in traces in the old system, making them unpredictable in practice.

  Celestial bodies are the largest and most long-lived objects with historicity, followed by the oceans and continents, the kingdoms of organisms, biocoenoses, languages and cultural artefacts—all fundamental physical processes. Lasers can serve as an example. A rubidium crystal, excited by an energy source, will emit a ray of light. The direction that light takes, however, is unpredictable thanks to the 'parliament of molecules' (Haken 1978); this is an event marked by shortest historicity.

  Of course, quite complex systems with very short historicity also exist. Examples include snowflakes, a rapidly emptied compost heap, or a piece of prematurely scrapped cultural legislation. These stand in contrast to complicated states such as metal shavings, a rubbish dump or a jabbering crowd, none of which are complex.

(ii) *Hierarchic organization* is a second feature and is related to *polymorphy*.

We find the most complex hierarchies, with up to 18 tiers (Riedl 1975), in higher organisms. Step by step—from atoms and molecules up to organs and individuals—each new tier exhibits phase transitions and manifests new emergent qualities, accompanied by yet another descriptive terminology. Cultures, languages and artefacts follow suit. The simplest systems, in turn, are textbook examples from physics. An example is Bénard cells (compare Nicolis and Prigogine 1987): heating a thin water layer from below and cooling it from above creates convection cells in which heated molecules rise up centrally and sink down along the outer margins.

One feature deserves mention here: redundancy. Although it does not determine hierarchy, it does influence the patterns of order in a hierarchy. Redundancy refers to the repetition of nearly identical structural elements. Examples include the hydrogen molecules of a sun, the molecules making up genetic material, the brain cells of an organism, the leaves of a tree, the spruce trees in a forest, the ties of a railway track, or the number of books in a particular edition.

Polymorphy alone, however, by no means determines complexity—despite being very high in a rubbish heap or landfill. The situation differs in hierarchies. Even the simplest hierarchy of structural elements or functions leads us to expect complex conditions. This points to the third group of features.

(iii) *System conditions in the narrower sense*. Complex systems are always embedded in a broader setting. This affects the modalities of that system's origin, maintenance and change, but it does not do so alone. The internal workings of a system gain autonomy and follow novel trends, constraints and degrees of freedom. And they are considerably more stable than changing environmental conditions because their fate can be intimately tied to such a system.

Gradients in expression can be expected here as well. The top tier again encompasses higher organisms, which pass along certain features over billions of years, followed by languages, all of which contain and separate nouns and verbs. Even architectural styles and false theories can persist for centuries, independent of the milieu, based on autonomous internal principles. Additional catchwords pertaining to complexity in this connection include feedback, multilateral and recursive causality, internal conditionality and stability principles.

This, however, already goes beyond the general definition of complexity and touches upon the level of research, of discussion and controversies.

(b) *Complexity is omnipresent*. In principle, a chemical bond or even a heavy atom already meet the definition of a polymorphic structure and of a functional interrelationship. Complexity is missing only when the component elements have not yet been linked or when we ourselves have disassembled or disrupted the link. In such cases, the historicity is blurred.

The definition excludes any accumulation of unrelated items such as those found in fresh garbage piles. The same holds true when polymorphism is lacking, such as in a pile of sieved sand. A sandy beach, however, does represent a complex system. Pure redundancy, such as that characterizing a dot matrix, should also be excluded. This is also valid for an absolute lack of redundancy, such as found in the garbage heap, or in an ahistorical randomness such as shattered glass. The amount of such disjunctivity and chaos that civilization produces is astounding.

(c) *The relevance of complexity* for living organisms is a reversal of the above-mentioned constellation. We live exclusively on complexity. In one sense that sounds trivial because we ourselves are complex systems. A single quantum of light might be sufficient to activate a melanocyte in our skin or to trigger dramatic responses after hitting our retina. In short, any environmental factor that stills our hunger, satisfies our urge for physical activity, elicits affection or gratifies our sense of esthetics is complex.

Our whole existence is anchored in complexity. To turn a phrase coined by Schrödinger: we feed on complexity, we live on its degradation.

At the same time, we are destined to create complexity. Complexity rules supreme in all things of value that cultures produce, whether in agriculture or animal husbandry, artefacts, organizations or ideas. All this forms a precondition for our survival, compensating for the degradation of order that nourishes us.

(d) *Our technical treatment of complexity*. The issue of complexity calls for special methodologies, terminologies and forms of depiction. The upcoming chapters are devoted to developing such terms and depictions. The first step (preceded by a preamble) is to broadly outline the methods.

This approach requires a few words about (d1) the synoptic approach and (d2) the stance behind it.

- (d1) *The ambition of the synoptic approach* stands in opposition to the traditional scientific method, in particular to that of the natural sciences. Subjectively, this approach tends to be relegated to the arts or, alternatively, the arts are touted as being the ‘spice of the sciences’. It pays to be objective.

  The sciences are commonly interpreted as being analytically oriented, but their terminologies already prove to be as synthetic as their systems and intellectual frameworks. Categorizing the sciences as being analytical is mostly based on their particularistic product. These a purely manners of speech. The fact remains that the sciences tend to subdivide our world into parts rather than pulling it together. This is patently evident in the successive dissection into disciplines and sub-disciplines, each with its own, unconnected scientific language and sub-language. This all runs counter to the vital necessity of comprehending the world and human thought as an entity, as a whole.

  The synoptic approach, in turn, appears to be largely synthetic (and speculative to boot). What, one might ask, can be synthesized if not analytically gained building blocks? Again, it’s the product that creates that impression.

The product itself is largely synthetic. The allegation of speculation also proves to be a mere preconception. This is because the cognitive process is characterized by a natural cycle of alternating synthesis and analysis, referred to in this book as inductive and deductive processes. And induction necessarily contains speculative elements: it is a necessary heuristic principle in all sciences.

Of course, a synoptic approach is always riskier for researchers than pure analysis. It is more risky intellectually, it is disparaged as a minority phenomenon, and it receives little funding because its products promise less profit or political influence. Nonetheless, foregoing this approach poses high risks for society's understanding and treatment of the world.

- (d2) We are actually ideally equipped for *synoptic tasks*, specifically for gestalt perception. The process is automatic and features an innate sensibility. It guarantees our survival by summarizing and sorting complex, highly polymorphic shapes and forms. Classical examples include the recognition of faces, species or styles. Such perceptions unerringly steer us through our complex world.

  Of course, this talent appears to be unevenly distributed. The same holds true for the often contrasted talent for mathematics and logic. The explanation remains unclear. Many researchers assume a brain hemisphere preference: an individual can rely either more on his or her left, analytic-deductive dominated brain half or on the right, synthetic-inductive half (see Chap. 4, Sect. 4.3). Another explanation is our subordination to modern educational approaches, which apparently favor left brain hemisphere problem-solving (compare Chap. 7, Sect. 7.2). In principle, synoptic tasks involve being motivated to synthesize and to draw comparisons (and to trust that this is useful).

### *1.1.3 Why, of All Things, Structures?*

There are apparently no functions without structures, at least in the macro-realm. Only in quantum physics do particles and their functions (the energy state of a wave) in some sense begin to coalesce. And the rule equally states: no structures without functions, or at least no structures without any effect whatsoever. If that is the case, then why start here with structures?

A second rule of thumb is that we discover phenomena through structures and explain them through functions. Although this needs to be challenged, the rule does contain a kernel of truth. Gestalt perception is required to experience structures, but not to experience function. We automatically perceive shapes and form, whereas explaining the accompanying functions requires a rational framework.

This insight serves to structure the main parts of this book: Chaps. 3 and 4 juxtapose our innate method of cognition with the constructional method of explanation presented in Chaps. 5 and 6.

This structure also mirrors another circumstance. It turns out that the explanation for a phenomenon can change without the matter itself changing. Vice versa, however, a new insight into a phenomenon immediately prompts a new explanation.

When dealing with complexity, the cognitive process is the prerequisite and more reliable element.

## 1.2 On Methods

A few additional terms and concepts help anchor the methodologies applied in this book. They all have accepted definitions and stem from biology, or from psychology and sensory physiology as biologically oriented disciplines. And they all exhibit a holistic character along with the cognitive ambition to integrate the processes of perception and of thought. The authors of selected 'key works' are briefly introduced in order to characterize the disciplines; later chapters provide more detailed discussion.

The task here is—building on terms rooted in biology (Sect. 1.2.1)—to present (Sect.1.2.2) those dealing with structure and function. Then, in Sect. 1.2.3 a discussion of cognition and explanation is used to (4) develop the framework for the overall argumentation.

### *1.2.1 Morphology, Systems Theory and Gestalt*

These schools of thought—as differently as they may have unfolded—all arise from the aura of biology.

(a) Morphology is a term stemming from biology or, more precisely, from 'comparative anatomy'. It can be traced back to the physician Karl Friedrich Burdach, was developed by Goethe, further advanced by Oken and Owen, and came to dominate classical biology as a whole. This is reflected in a remarkably rich literature, albeit one whose theoretical underpinnings were largely formulated outside the English-speaking world.

Morphology serves as the first methodological approach. Firstly because no other discipline can boast more experience in cognition and greater achievement in comparative tasks. Two million species multiplied times an average of at least ten unique anatomical features have yielded over 20 million terms (names)—five times the vocabulary of all the major languages combined. Secondly, morphology—as the name implies—is the science of form (gestalt) or, more precisely, the interpretation of form. It is therefore 'epistemological' and helps resolve the interplay in analytical-synthetic processes. It provides the framework for all practical endeavor in comparative anatomy and phylogenetics and is the cornerstone of every comparison involving complex systems.

Structuralism, which is closely related to morphology, is treated further below.

(b) *Systems theory* has also developed from biology. It can be traced back to my teachers von Bertalanffy and Paul Weiss in Vienna and deals with the causal relationships in complex systems, in particular their interdependencies. In contrast to morphology, which has only minimally influenced the cultural sciences, systems theory has permeated almost every science. This includes the study of cognitive processes.

(c) The term '*gestalt*' comprises more than today's colloquial 'form', 'structure' or 'pattern'. It comes from the German word '*gestellt*' and describes the act of forming. Accordingly, it incorporates the viewer him- or herself, i.e. the person transforming perceptions into gestalt. This recursive concept has been absorbed virtually unaltered by other languages. It also harbors a theoretical component that spread from Austria and southern Germany, initially through Ehrenfels, Koffka and Wertheimer, in the form of *gestalt theory*. This became an important concept in the early twentieth century. The theory goes a step beyond the field of psychology but remains rooted in the phenomenon of perception.

    In the upcoming topics, these concepts form a troika for delving into the synoptic tasks of cognition and the structuring of theories.

### *1.2.2 Structuralism and Functionalism*

The methods of morphology, because they are supported by gestalt perception, were soon no longer scrutinized: morphology was once again practiced intuitionally and taken to be equivalent to comparative anatomy. Its theory remained rooted mostly in the German-speaking world, but its subject matter blossomed and became indispensable. While this was insufficient to trigger a true renaissance, it did usher in a thematic substitute.

The task here is to juxtapose (a) structuralism with (b) its counterpart (functionalism) and to recognize the (c) relationship between the two.

(a) *Structuralism* originated from the French linguistic tradition and was expressed by Lévi-Strauss (1968) before being picked up by the developmental psychologist Piaget (1973) and ultimately reaching contemporary, English-speaking authors.

    Structuralism presages a relationship with morphology. It cites Geoffrey Saint Hillaire and the English authors Owen, Gregory Batson, D'Arcy Thompson and Waddington, refers once again to holism, transformation, self-regulation, organization and order, and espouses two important views. First (i) it demonstrates that, beyond the functional explanations provided by Neodarwinism, additional 'inner principles' must be at work that help understand the product of evolution. Second (ii) it highlights that—beyond the diachronic, explanatory approaches to the problem—synchronous, 'descriptive' approaches must be postulated in order to better comprehend the phenomenon of evolution.

(i) The former view involves terms from holism and systems theory, superimposed on Neodarwinism.
(ii) The latter view approximates the distinction between cognitive and explanatory approaches, two concepts that form the main body of this book and that are juxtaposed in Chaps. 3 and 4 versus Chaps. 5 and 6. The proponents are mainly authors from the 1980s such as Ho (1984), Hughes and Lambert (1984), Rieppel (1990) and Webster and Goodwin (1984). The methodological difference between the two approaches has never been clarified. One might think that manners of speech, 'ways of seeing', are involved. 'Rational morphology' may come to mind, although 'rational' is a misnomer because the word also means 'reasonable', 'practical', or even 'purposeful'. Defining the methods turns out to be the key issue, and this book is devoted to that task.

(b) The term *functionalism* encompasses the fundamental paradigm behind mainstream natural sciences per se, namely ongoing reductionistic causalism. In the case of evolutionary theory, this spawns the expectation that random mutations and environmental selection alone provide a satisfactory explanation.
(c) We clearly need to consider *the interplay* between the two interpretational directions. The term 'functional structuralism' has even been introduced to reflect this. Functions are naturally attributed to structures. Equally, in the macroscopic realm—whether it involves physics or cultural products—functions are never perceived without the attendant structural elements. Only when descending into the realm of microphysics do the borders between functions and structures (waves and particles) become more fluid. I caution against mixing the two perspectives: even their methods differ fundamentally. This is a core issue of this book.

### *1.2.3 On cognition, Explanation and EE*

EE—evolutionary epistemology—underpins the theoretical framework espoused here. The theory of evolution takes on a core role because EE itself can be understood as a satellite theory of the evolutionary perspective.

Accordingly, (a) EE can help to differentiate the processes of (b) cognition and (c) explanation.

(a) Evolutionary epistemology studies the hereditary basis of the human psyche, of our social and—more interesting in the present context—our cognitive performance or faculties. It holds that this performance is the product of our adaptation to extra-subjective reality. It also incorporates the history of human organization. This theory was anticipated by Ernst Haeckel, brought to paper by Konrad Lorenz and then further developed in the 1970s by Lorenz, Campbell, Vollmer and myself. Chaps. 2 and 3 are devoted to this approach.

Evolutionary epistemology is also closely related to another biological discipline, namely comparative ethology, which itself again presupposes the theory of evolution. EE has also become integrated into numerous other disciplines in the natural sciences and humanities (Riedl and Delpos 1996b), ranging from mathematical theory and physics to law and political science. It has also granted me numerous insights into the methods of science (Callebaut 1993) and, importantly, the recognition that the methods of cognition and explanation differ considerably from one another.

(b) *The process of cognition* is 'ratiomorphic', i.e. it resembles reason but is clearly not rational in the strict sense. Rather, it operates on a largely preconscious level and is directed at recognizing rule-based or 'lawful' simultaneity. This has been only poorly studied, and its outputs are therefore experienced as being gained intuitionally (see Chaps. 3 and 4). Clarifying this conundrum is doubly useful. First, it clears out the misconception that the method is unscientific (based on a perceived ignorance about its structure) despite its recognized, fundamental role and high reliability. Second and most important, this method is eminently suited for dealing with complex phenomena.

(c) Although *the explanatory process* also has a ratiomorphic basis, it ultimately operates consciously. It is directed at detecting and unravelling lawful successions of events: it is considered to be well studied, its outputs are experienced as rational constructions, it is downright paradigmatically held to be scientific, and it alone is considered to be acceptable in the framework of the so-called exact natural sciences. Chaps. 5 and 6 compare and relativize the explanatory and the cognitive process, especially because the former depends on the latter and is itself less suitable for deciphering complexity.

### *1.2.4 Biology as the Conceptual Framework*

In retrospect, biology has clearly delivered most of the tools required for tackling complex systems. This reflects biology's unparalleled experience in dealing with complexity, ultimately under three conditions. These conditions need to be set in relation to their consequences.

Biology experienced (a) a schism of methods early on. It also strove (b) to elucidate the cognitive processes and (c) to rebut the allegation of 'biologism'. This effort exposed (d) the gradients behind the methodological schism, yet without (e) intermixing the methods themselves.

(a) The *methods of biology* lie at the crossroads between those of the inorganic and cultural sciences. Biology's physiological disciplines, down to molecular biology and biophysics, operate in a causalistic, explanatory manner. Their underlying (yet unattainable) ambition is to trace even the most complex phenomena back to the laws governing matter. In contrast, anatomists and systematists operate morphologically and comparatively. Their 'hermeneutic' approach follows—as this book will demonstrate—a recursive method of 'reciprocal enlightenment or illumination', an approach that characterizes the humanities as well.

At this point, biology starts to unravel, revealing thinly veiled misunderstandings. This is the impetus to untangle the misleading schism along with its methodological implications. This second ambition is to dismantle the schism between the exact natural sciences and the humanities. Taking the task of deciphering complexity seriously means not shying away from the ultimate litmus test—addressing the complexity of the sciences themselves.

(b) *Cognitive patterns and natural patterns* must, asserts EE, be complexly interrelated. This is ultimately an epistemological issue involving the nature of knowledge.

Clearly, many of us have become diligent citizens of our planet and equally capable researchers without having delved into questions of cognition. Nonetheless, we can all benefit from recognizing the process behind grasping a situation and gaining knowledge. The heart of the matter is the degree to which the structure of our thought processes mirrors that of extra-subjective reality.

(c) The term *biologism* refers to a very specific type of allegation. It is directed against a worldview holding that mental and social phenomena are attributable entirely to biology. This critique is both imprecise and unfair. Of course, all laws governing 'deeper' layers permeate the successively 'higher' ones. This makes them necessary but by no means sufficient to comprehend and explain the higher tiers.

The laws of physics and chemistry indisputably operate at the organismic level. They prove to be vital for all life processes. At the same time, their action alone does not define life. Perception, activity and needs are new, superimposed qualities. Every level must be viewed on its own. In many cases, no traces of the newly emerged qualities in a particular tier can be detected in the constituents of the preceding tier. Logic, religion and literature, for example, have no roots in the animal kingdom. Nevertheless, the laws of biology are essential for the existence of humaneness, for social and cultural traits. They are necessary—yet at the same time insufficient—to perceive and explain humanity.

Putting the above to pen may seem almost trivial, but the central role played by biological methods and biological insights make this perspective very helpful indeed. Overall, it is fair to say that biology has attained a new status.

(d) *Three gradients* differentiate the two methods along the entire spectrum of complexity in the sciences.

This context is evident in (d1) the conventional arrangement of the sciences, in (d2) the degrees of complexity in the inorganic realm, and in (d3) the methodological overlap.

- (d1) The *conventional arrangement* of the sciences represents a gradient. For every science, that gradient extends from a typical or core manifestation to some irrelevant or inapplicable endpoint. This is equally valid for the causalistic method of inorganic chemists and physiologists as it is for the hermeneutic, comparative approach of morphologists and humanities scholars (Fig. 1.1).

Here, ‘conventional’ disciplines are understood as being those traditional university subjects that adhere to the particular horizons of complexity defining their objects. They develop theories about a specific cross-section of the world. The concept of ‘longitudinal theories’ will be introduced later to refer to efforts that, like the theory of evolution, chaos theory or systems theory, seek to unite all the levels under a particular point of view. Some of these will prove useful here, yet belong to another type.

The modus operandi of physics is causalistic. All phenomena are attributed to the four physical interactions (weak and strong nuclear forces, electromagnetism, gravity). Such energy transformations indisputably underlie forms of human endeavor such as the arts. At the same time, explaining a school of art, such as that of Raphael, based on nuclear forces and gravity would miss the point. Rather, the analysis would start by comparing artistic creativity and invoking gestalt perception. In contrast, the analysis of elementary particles in physics would benefit little from introducing gestalt perception—even if shapes and forms are visible in the bubble chamber.

A ‘physics of culture’ or an ‘atomism of cultures’ would do little justice to physics as a discipline. A ‘culture of the inorganic realm’ or a ‘comparative culture of atoms’ would be equally senseless (Fig. 1.1).

When viewed from such inapplicable endpoints, this seems so self-evident as to render the entire matrix trivial. Nonetheless, the gradients of complexity of the

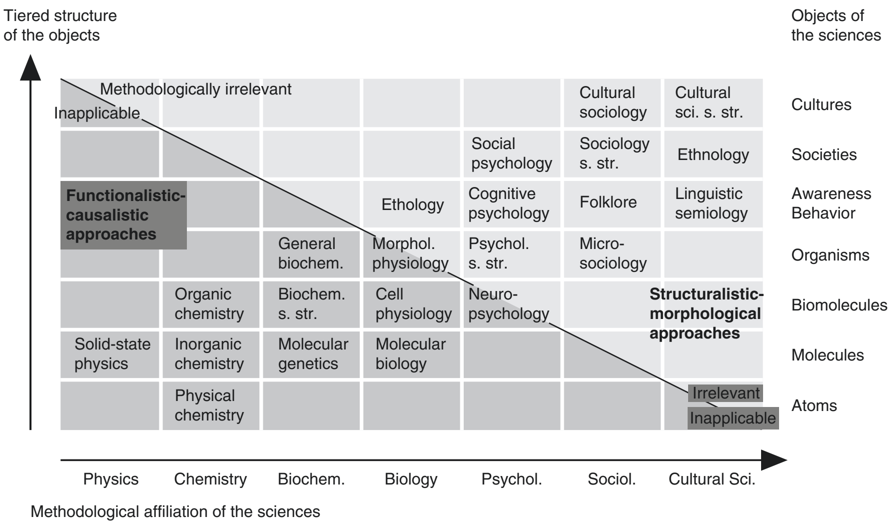


**Fig. 1.1** Arrangement of conventional sciences based on their level of complexity and the degree to which the causalistic versus morphological method is applied. The irrelevant or methodologically inapplicable ends of the matrix are indicated. Morphological treatments of the objects of physics are irrelevant (methodologically inapplicable). In causalistic treatments of cultural objects, complexity is irrelevant (s. str, sensu stricto)

objects treated by these disciplines (Fig. 1.1) reveal a transitional field for the causalistic and the morphological approaches. Biology takes a central position in this field, where the methods either conflict with or augment one another.

- (d2) The *degrees of complexity in the inorganic realm* are also instructive. Starting with structural chemistry and proceeding to mineralogy, geology, geomorphology and physical geography, the structurally perceptible features gradually increase in size until, ultimately, they dominate entirely. In that same sequence, the causalistic perspective wanes and the structural perspective waxes.

  In mineralogy, insights may be prompted by gestalt perception, but many of the structures can still be causally attributed to the shapes of the component molecules and ultimately to the laws governing chemical bonds. In physical geography, however, at the other end of the series, gestalt perception dominates. Clearly, the form and position of today's continents can be causalistically attributed to the distribution of masses in the Earth's crust, to fluid and tension forces. Nonetheless, factoring all this in would yield less new insight than a good map of Africa.
- (d3) This leads to the issue of *methodological overlap*, to the possibility of examining the same object both causalistically and structurally. This will be treated more in-depth later and is an essential perspective for a deeper understanding.

  It suffices here to state that this possibility arises when the prerequisites for both gestalt perception and for causality are fulfilled. On the one hand, an object must be sufficiently differentiated to warrant a comparison within a 'field of similar forms'. This degree of complexity is already evident at the level of mineralogy. On the other hand, making useful statements requires that the sector we seek to explain causally not be too far removed from elementary conditions. In principle this can extend up to the complexity level of cultural sciences, as demonstrated by examples from economic theory. The limits of a sector are defined by the bounds beyond which we can expect practicable results either only from a causalistic or only from a gestalt-oriented approach.

(e) *Intermixing the two methods* must be strictly avoided regardless of how well they supplement each other. Both involve such different approaches and are subject to such different forms of validation that any amalgamation can only cause confusion.

From the cognitive perspective this is a curious situation because complex things—from the inorganic to the cultural realm—comply with the same laws that governed the make-up of our brains. After all, natural scientists and humanities scholars still prove to be 'crossable', at least experimentally.

# Chapter 2
# The World and Cognition as a Problem

From the biologist's perspective, the phenomenon of perception as well as the problem of cognition need to be examined in a manner that philosophers will find unusual. This is because, for biologists, cognition is already relevant in animals, whereas philosophers set their sights on humans, on the semantics and syntax of our culture. Cognitively, this is accompanied by a subliminal pursuit of truth. It turns out, however, that consciousness followed by deliberate, critical reflection were prerequisites for making cognition and perception into phenomena that unmask the deficits behind knowledge and truth.

This calls for distinguishing (Sect. 2.1) what appears reasonable to us, (Sect. 2.2) how knowledge is gained and (Sect. 2.3) what kind of knowledge we in fact possess.

## 2.1 What Appears Reasonable to Us

Raising the question why human reason harbors such unreasonable streaks reveals that two different types of reason are involved. The first simply refers to our clear-mindedness, setting us apart from 'dumb animals'. Ever since Kant, philosophy also understands this level as being characterized by the development of concepts and the intellectual capacity to recognize relationships and draw conclusions. Irrationality, in contrast, encompasses the unreasonable behavior that impedes success and reduces the quality of life—key concerns in this book.

Making the world and cognition into a problem is quintessentially human. Fertility figurines fashioned tens of thousands of years ago and funeral rites that date back 40,000 and 60,000 years show that this characteristic, metaphysical problem must have originated very early on. Even back then, it was coupled with the existential question of where we come from and where we are going.



R. Riedl, *Structures of Complexity*,
https://doi.org/10.1007/978-3-030-13064-0_2

For some, this issue may have lost urgency because it doesn't seem to reach much beyond the perceptible natural world we encounter on a daily basis. Nonetheless, open questions do remain. And pondering questions that go beyond personal knowledge is clearly a mark of every thinking person. If our cosmos arose from a Big Bang, which I posit as still being the most acceptable theory, where then did all that energy come from (especially without the pre-existence of space and time)? Such questions can be raised without any expectation of a definitive answer.

This means that metaphysics cannot be sidestepped. Pursuing 'speculative metaphysics' promises little gain because it strives to derive the world from the highest of supposed principles. 'Inductive metaphysics' (Hartmann 1964), however, provides a way forward because it reveals the preconditions that we accept when we—in every branch of research—extend our query from the known to the unknown. Metaphysics therefore accompanies us, consciously or not, in our inevitable ambition to ask 'off-limit' questions (for example what caused the Big Bang?). Nonetheless, we need to accept that it is not the most dependable of guides.

The problems surrounding how we understand the world are of a more fundamental nature. They begin with the contradictions between what our hereditary 'cognitive apparatus' suggests and what conscious reflection concludes. Accordingly, the problem hovers somewhere between experience and reason, empiricism and rationality. This calls for taking a position.

The first step is to deal (Sect. 2.1.1) with consciousness, (Sect. 2.1.2) with the validation of knowledge gain and (Sect. 2.1.3) with the difference between forms of perception and language. This provides the basis for differentiating our questions and solutions.

### *2.1.1 What Arose with Consciousness?*

How did early humans handle the many puzzles that surrounded them in everyday life? Who could be behind all the hardships and indignities our ancestors faced and with what entities did one have to arrange oneself or beseech? Wasn't there some sort of intent—much like their own intentions and the intentions of those around us—which bore responsibility for all these adversities?

This gave rise, either by revelation or rumination, to the gods, which stood apart from the recognizable natural objects. These were initially conceived as being demons, then endowed with all the good and especially all the bad characters of humans, finally transformed into loving fathers, whereupon humans discovered their own god-like nature. The development of this worldview, however, was marked early on by critical voices, for example by those of pre-Socratic thinkers at the very roots of our culture (compare Capelle 1968).

A relevant sentence by Anaximander (611-545 BC) has been preserved. "I write what I believe to be the truth, because the lore passed on from the Greeks appears to me to be too much and too absurd." And there we have it: the problem of truth has been raised. It came to take on many iterations and has accompanied us ever since.

This issue, with its many inconsistencies and contradictions, can also be formulated as a dilemma (see Sect. 2.1.3).

(In the philosophy of the modern age, Kierkegaard elaborated this into a problem of human existence, Nitzsche and Dilthey into a 'life philosophy', Sartre into a type of nihilism, Heidegger and Jaspers into an 'existential philosophy'. Its influence on literature was considerable, on the sciences minimal. This need not be pursued further here.)

For our topic, the above development raises the question of how we actually perceive things and gain knowledge. In the language of philosophy: "How do the defining characters of the object transpose themselves onto the subject?"

### *2.1.2 The Conceivable Validations of Perception and Knowledge Gain*

In humans, a relationship of some sort must exist between extra-subjective reality and our senses and thought processes. Interestingly, cultural history reveals only few attempts to develop such a validation into a well-reasoned system.

As an introduction, I juxtapose the (a) transcendent, (b) the transcendental and (c) the evolutionary methods.

(a) The oldest attempt was developed by Plato (427-347 BS) in his '*theory of ideas*". In brief, he assumes that, beyond the physical world, there are principles in which both the objects constituting extra-subjective reality and the 'soul' of the subject 'participate' in. These ideas behind all things are mirrored in our concepts. This is referred to as a 'transcendent' principle, i.e. one standing 'above and beyond' the physical world. This has survived until today in the traditions of idealistic philosophy and Christianity.

    Aristotle (384-322 BC) presented a more worldly interpretation. He assumed that the 'particles' that make up our senses are similar to those of the outside world, enabling a match. Whether this represents a complete theory of cognition is open to debate. Nonetheless, this assumption principally underlies the work of all natural scientists.

(b) Kant (1724–1804) developed a theory based on the possibilities of gaining experience. He termed this attempt at establishing a foundation 'transcendental'. Accordingly, all knowledge is gained via the senses, but this knowledge must be anchored in a perception of spatial and temporal continuity (intuition) and in categories of perception that must be present a priori (i.e. in advance). These are the prerequisites for experience itself. They themselves, however, cannot be derived based on experience itself. This view had an enormous impact on the subsequent history of intellectual endeavor despite being unable to validate this specific a priori.

(c) Biologists find it difficult to accept that a clear prerequisite for engaging with the world cannot be substantiated or validated. Ernst Haeckel foresaw the solution, and Konrad Lorenz rose to the challenge when he was appointed head of the Department for Comparative Psychology in Königsberg, in the 'after-shadow' of Kant. In biology, doesn't the phrase 'given to life-forms in advance' mean 'innate'? Accordingly, innate forms of perception must fit the world for the same reason that a fish's fin fits the water even before it slips out of the egg (Lorenz 1941). The a priori in ontogeny can be *a posteriori* learning products of phylogeny—a product of adaptation. Evolutionary epistemology was born and began to spread with the books of Lorenz (1973a), Vollmer (1979) and Riedl (1980).

The adaptational explanation for our innate forms of perception and our categories proved to be the prerequisite for the solution, albeit still insufficient. It soon became supplemented by a constructivist element (Riedl 1995a) in the sense that the history of every biological system sets limits to its own adaptational possibilities. This perspective shed lights on deficits in our own adaptations.

Philosophers (Engels 1989; Pöltner 1993 and others) were skeptical about validating cognition based on the evolution of organisms (overviews in Riedl and Wuketits 1987). Many researchers, however, derived clear benefits from this approach (Riedl and Delpos 1996b). As has been demonstrated time and time again over the course of history, philosophical problems can be resolved scientifically.

### 2.1.3 Forms of Perception Versus Communication

Beyond dealing with the conditions of cognition, we need to examine the conditions behind our language or, more specifically, behind the thought processes underlying language. This aspect remarkably influences how we believe we need to see the world and how we engage with it.

For an easier orientation, the issues of (a) adaptation (b) its limits and (c) the forms and the development of selection criteria are discussed separately.

(a) It proves to be relatively easy to demonstrate that human perception has arisen *adaptively*. Among all conceivable programs that could have arisen in our cognitive apparatus, those that promoted survival under the conditions early humans faced in everyday life have gained foothold. This pertains both to the perception of spatial and temporal continuity (intuition) in the sense of Kant and to the categories (cognitive processes) that we in our terminology refer to as forms of perception.

In our daily lives, it has proven reasonable to reckon time as being one-dimensional and, independently thereof, to view space as being three-dimensional. This notion remains operational even though, in mega-cosmic dimensions, it has been disproved by the discovery of a generally valid (i.e. also meso-cosmic) space-time continuum. Our physiological clock, however, ticks in one dimension only, and our own bodies are built based on three spatial axes that we perceive