Biocommunication and Natural Genome Editing
Günther Witzany

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Springer
Preface

I wrote this book for biologists and those who are interested in both biological affairs in general and perspectives which integrate a large number of specialised biological disciplines.

The theory of biocommunication presented herein investigates signal transduction processes among cells, tissues, organs and organisms in bacteria, animals (corals and bees), fungi and plants in the light of the current available empirical data. Because life is the central focus of the life sciences, this theory will also focus on typical features of life as opposed to inorganic matter.

Because this field of investigation is based on the methodological primacy of a pragmatic action theory, the book may also be of interest to researchers of linguistics, communication sciences and sociology (e.g. plant sociology, animal sociology) who would welcome an overview of these highly specialised biological disciplines.

Current molecular biology as well as cell biology investigates its scientific object by using key terms such as genetic code, code without commas, misreading of the genetic code, coding, open reading frame, genetic storage medium DNA, genetic information, genetic alphabet, genetic expression, messenger RNA, cell-to-cell communication, immune response, transcription, translation, nucleic acid language, amino acid language, recognition sequences, recognition sites, protein coding sequences, repeat sequences, signalling, signal transduction, signalling codes, signalling pathways, etc.

All these terms combine a linguistic and communication theoretical vocabulary with a biological one. In this book I try to introduce an appropriate model to exemplify this vocabulary (which is used in biology all the time without people thinking about it), on the basis of explanation and understanding of a linguistic action, the great variety of communicative actions.

Many biologists are not very familiar with current definitions of ‘language’ and ‘communication’ in contrast to linguistics, communication science, pragmatic action theory, sociological theories. If we speak about (i) the three categories of signs, index, icon and symbol, (ii) the three complementary non-reducible levels of semiotic rules’ syntax, pragmatics and semantics and (iii) communication as rule-governed sign-mediated interactions, it can easily be seen that all these categories are nearly unknown in biology, especially in molecular biology, cell biology, genetics and related disciplines.
Most biologists who use linguistic and communicative vocabulary to describe biological or genetic features do this according to their methodological self-understanding as empirical natural scientists. ‘Language’ and ‘communication’ are investigated in natural sciences behaviouristically or in the realm of formalisable procedures, i.e. algorithms with information-theoretical, statistical or systems-theoretical conclusions.

In contrast with this linguistics, communication theory, semiotics and especially pragmatics, as well as action theory, have tapped knowledge about language and communication which was unimaginable 40 years ago. It is completely different from fundamental suppositions of older, mechanistic, behaviouristic and even information-theoretical definitions. In the light of this current empirical and theoretical knowledge it has become increasingly clear that the multiple levels of sign-mediated interactions which we call ‘communication’ cannot be explained or even sufficiently described by older models such as the ‘sender-receiver’ narrative or even based on the term ‘information’. Even physicalistic or mathematical definitions of language as quantifiable sets of signs fail to describe key features of these phenomena.

The current theory on biocommunication does not want or is unable to replace empirical biology. Conversely, the recent quality of empirical biology is the prerequisite for a theory of biocommunication. Because natural sciences are not familiar with appropriate definitions of ‘language’ and ‘communication’ as both terms are in current action theoretical investigations this theory of biocommunication should be a complementary tool for e.g. biology. The theory of biocommunication then could act as a complementary tool in the interpretation of available empirical data concerning biological affairs.

The question is how we unite ‘language’ and ‘communication’ with biology. Why is it so comfortable and useful to operate with linguistic and communicative terms in biology? Are there any advantages for biology in research and teaching through a pragmatic theory of biocommunication? What is its traditional background, i.e. what is its place in the history of science? In this book I try to give answers to these questions. May I invite you to trace with me the roots of biocommunication?

Bürmoos, Austria
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Günther Witzany
The first concept of the theory of communicative nature I published in 1993, a philosophy of biology in ‘Natur der Sprache – Sprache der Natur. Sprachpragmatische Philosophie der Biologie’ (Würzburg 1993) and its english and updated translation, ‘Life: The Communicative Structure’, followed some years later (Norderstedt, 2000). This new philosophy of biology was now recently applied in this concept of biocommunication. I have been privileged to hold excellent discussions with these outstanding experts, who encouraged me to develop this new approach. I want to thank Annemarie Pieper, Hermann Krings, Wilhelm Vossenkuhl, Rupert Riedl, Thure von Uexküll, Kalevi Kull, Don Favareau, Peter Harries-Jones, Frantisek Baluska, Peter Barlow, Frank Ryan and Luis Villarreal. For technical support I want to thank Wilhelm Hasenauer, Pierre Madl, Michael Stachowitsch, Karl Mayr and for everyday intensive communication Hiltrud Oman. Pierre Madl I want to thank for co-authorship of chapter 4, Biocommunication of Corals. I like to dedicate this book to the memory of my outstanding philosophy teachers Zeno Bucher and Beda Thum. Additionally I am grateful to Catherine Cotton, Ria Kanters and Ineke Ravesloot for excellent support during the preparation of this publication.
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Abstract  First, I offer a short overview on the classical occidental philosophy as propounded by the ancient Greeks and the natural philosophies of the last 2000 years until the dawn of the empiricist logic of science in the twentieth century, which wanted to delimitate classical metaphysics from empirical sciences. In contrast to metaphysical concepts which didn’t reflect on the language with which they tried to explain the whole realm of entities empiricist logic of science initiated the end of metaphysical theories by reflecting on the preconditions for foundation and justification of sentences about objects of investigation, i.e. a coherent definition of language in general, which was not the aim of classical metaphysics. Unexpectedly empiricist logic of science in the linguistic turn failed in the physical and mathematical reductionism of language and its use in communication, as will be discussed below in further detail. Nevertheless, such reflection on language and communication also introduced this vocabulary into biology. Manfred Eigen and bioinformatics, later on biolinguistics, used ‘language’ applied linguistic turn thinking to biology coherent to the logic of science and its formalisable aims. This changed significantly with the birth of biosemiotics and biohermeneutics. At the end of this introduction it will be outlined why and how all these approaches reproduced the deficiencies of the logic of science and why the biocommunicative approach avoids their abstractive fallacies.

1.1 Metaphysical vs. Mythological Construction of Nature

Linguistic and communicative vocabulary as a crucial tool in scientific foundations and the methodology of philosophy of science has been in use for 70 years. Before this time, empirical descriptions of non-living nature and even living nature were derived from metaphysical constructions with a long and complex history embracing the most prominent thinkers in occidental philosophy. All of them tried to give answers to the classical antinomies which derived from the Athens school of Greek philosophy. Before I give a short reconstruction of the metaphysics of nature I want to give a synopsis of what the metaphysical thinking opposed. It was a central
paradigm shift in human history: the change from a myth-based self-understanding with its focus on cultus and ritus and the strict hierarchy of norms and traditions within which a tribal society was interwoven. Pre-metaphysical hierarchies are mythology-based forces of creation. Nature was speaking to humans as animals and plants, natural forces as thunder, wind, water and fire. The order of the world was self-evident. Animals were not ranked inferior to humans but equally. As animals are different, so are humans different. The self-evident order of the world is a cosmos-centric law which rules over animals and humans. The myth of the change of nature before humans to nature with humans does not resolve the status of nature without humans. The mythology of pre-metaphysical tribal societies suppresses destruction of nature definitively. Nature is a kind of holy being within which non-holy humans are embedded. Therefore humans have to act accordingly.

Humans in pre-metaphysical tribal societies were not only ecological experts. Their educational systems were holistic ones, each member being required to be familiar with their surroundings such as plants, animals, climate, annual cycles and repetitions, interdependencies of the inner and outer nature. Each member of this kind of human society was also familiar with the ethics and norms of tribal traditions in social affairs.

A different relationship with nature was constructed in the metaphysical thinking of the classical Greek philosophers. At the basis of the western occidental-modern world view and technical-scientific modernity we can find Greek cosmology. Their competing metaphysical world views are extensively developed constructions according to logics and methodology which offer completely different answers to questions of the myth-based lifeworld.

The change from a natural being into a society-based being is an irreversible process. The division of survival of society, of the survival of non-human nature, indicates a newly-derived hierarchy in which culture (i.e. inner nature of humans) has primacy in opposition to nature (outer nature). The subordination of society to an omnipotent creator god and his plan of creation are followed by the subordination of non-human nature to the human one. The hierarchy is strict and structured: the primacy of gods, followed by humans and, last, the rest of nature. The age of unity between human mankind and nature is broken irreparably. The order of the world is no longer self-evident but offered by god and supernatural. God is thinking prime pictures whose depictions are manifested in a great variety here on earth and in the cosmos (Capelle 1968).

The invention of the general term as crucial tool of the technique of abstract thinking divides metaphysical interpretation of nature clearly from the pre-metaphysical one.

The rationalisation of world views occurred in parallel with differentiation and complexity of writing. Development and practice of the technique of writing liberated transport of tradition from the ancient practice of vocal traditions. Now it was possible to read about the history and myth of tribal societies even if they were far away or no longer present. Metaphysical philosophy of nature from now on had to answer the questions of classical antinomies, the relation between the whole and its parts and between (statical) being and (dynamical) becoming.
There are three mainstream conceptions within metaphysical philosophy of nature in the occidental tradition of philosophy of the last 2000 years. All philosophica conceptions of the last 2000 years are part of one of these mainstream paradigms.\textsuperscript{1} We differentiate:

- Monistic-organismic world views
- Pluralistic-mechanistic world views
- Organic-morphological world view

\subsection*{1.1.1 Monistic-Organismic World Views}

The main principle of all monistic-organismic world views is holism (all is one). What we experience as a broad variety of things and processes constituting this world is attributed to one main principle. The multitude of beings is within this world view deduced from one driving force. Cosmos is a whole, the many things are epiphenomena which seem to be many but in reality are only parts of the whole. Inside and outside are two aspects of the one and whole reality. What seem to be many are only different moments of the one and all. According to different wholes in this monistic organismic world view (Life, soul of the world, world-mind, god) there is a differentiation between a physical, metaphysical or pantheistic monism. If the main principle is life we speak about hylozoism, if it is the soul, panpsychism, if it is divine, pantheism. In all of these monisms there is one and only one main principle which is behind all things. In the history of philosophy we can differentiate different developments of these monisms such as pre-Socratic hylozoism (Thales of Miletus, Anaximenes, Heraclitus), cosmic pantheism of the Stoa (Seneca, Epictetus, Marcus Aurelius, Cicero), pantheistic emanantism of Plotinus (Ammonius Sacca, Plotinus, Scotus Eriugena and later on Spinoza, Hegel), aesthetic pantheism of Giordano Bruno and his monadology, which was further developed by Leibniz and the pre-critical Kant in his metaphysical dynamism, and later on Hamann, Kierkegaard, Schelling, Goethe, Novalis, Hölderlin, Rilke, Steiner.

In a certain sense, this monistic world view is exemplified also in rationalism with its objection that the whole world can be imagined as and integrated within one objective and logical system which we must solely investigate long enough to integrate all things into this one and only system, as thought by Spinoza. This thinking also attracted Hegel. The god of Hegel is living and organismic and emerges as world through dialectical processes of birth, death and next level of being. In its organismic variation we find monistic evolutionism in Clifford, Huxley, Darwin and Spencer. One law determines the whole universe. This absolute unifying law is the law of development. Differentiation and Integration are the everlasting potentials of this law. The Emergentism of Samuel Alexander postulates the one and only world matter which is the material out of which all things are formed. The many parts and

\textsuperscript{1}The outline of the three metaphysical world views follows Zeno Bucher (1982). Natur, Materie Kosmos. Eos, St. Ottilien.
processes are events which are emerging out of this world matter which is at the last identical with god.

Another much younger philosophy is the panvitalistic metaphysics of France with Maine de Biran and Bergson. From its strict anti-mechanistic and anti-rationalistic view they propagated a self-enforcing power of all living, or as Bergson called it, the Bios, the principle of creation in the whole reality which is the driving force of the whole universe. This vitalism is integrated within certain other holisms which tried to unify this world view with modern natural science knowledge and such proponents as Haldane, Meyer-Abich, Wheeler, Whitehead, Bohm, Capra.

Another kind of organic monism is the dialectical materialism of Engels which is a counterpart to Hegel’s idealistic monism. The whole and the one is more than the sum of its parts. The parts per se have no value, only in sum the whole is the main value.

The monistic-organismic world view is present also in twentieth-century physics. Searching for the last common invisible matter, or the elementary parts of all matter or the last one formula (Stephen Hawking) through which all can be explained or which represents the ultimate law of all being, are variations of ‘all is one’ – metaphysics. The particles on the subatomic level are not parts by their own. They are parts which are all constituted by lower parts and smaller parts and at the last they are quantums, quantum parts (Heisenberg 1973) or, as Einstein noted 1950, electrical field densities which we see as corpuscles but in reality are condensed out of a universal field of energy.

The driving force of these monistic-organismic world views derives from both the presumption of the unification of thinking and being (without language’s critical reflection) and a kind of idealistic rationalisation of experiences such as separation, transitoriness, contradiction, fear of reality and the new, unexplainable. The many parts we experience are at the last all in one, a common principle, the last and ultimate law and formula or in its theistic variation basics of all religious social orders (Wittgenstein 1975: 80e).

1.1.2 Pluralistic-Mechanistic World Views

In strict opposition to the monistic-organismic world views there are the pluralistic mechanistic ones. Their main principle is: all is endless plurality (all is many). In contrast with the holistic one and only of monisms, in the pluralistic all is built of indefinite numbers of corpuscles, smallest parts. If we look at or experience things, persons, objects, they seem to be entities, but in reality they are the sum of these smallest corpuscles. These last smallest entities are unchangeable and everlasting. A real becoming out of nothing, i.e. a real de novo emergence which means a movement from not being into being may be a construction in our consciousness but has nothing to do with any reality. These ultimate single corpuscles can be brought into forms or can even be mixed but this does not change anything within them. In their outer nature they can be moved and change their relation to one another but in their substance they are unchangeable. Any movement is caused from outside and is
purely mechanistic. Parmenides was one of the first thinkers to propound this world view. For him movement is also an illusion because it is a line-up of the smallest unmoved statical state of things.

A hundred years later the atomistic school changed the philosophy of Parmenides in one crucial aspect. Leukippus and Democrites now believed the experience of multiplicity, changeability and movement to be reality. The hylomorphistic conception of Aristotle damaged this world view until it was revived by Pierre Gassendi in 1649. He constituted the philosophy of mechanistic atomism in a new way. Robert Boyle described this mechanistic atomism. He observed that in contrast with older forms of atomism matter is an assembly of different basic elements. His philosophy focused on investigations and research into these basic elements. A hundred and fifty years later Proust and Dalton postulated real atoms in the so-called law of constant and multiple proportions.

Then the term molecules was developed and in the shift to the twentieth century it became increasingly clear that atoms are not atoms, because they are constituted by a variety of dynamic entities which can emerge as corpuscles or waves. This contradicted the term atom fundamentally. Although atomism was shown to be a misinterpretation of nature, Mechanism as mechanism has been a successful model until today.

René Descartes observed earlier that the concept of indivisible corpuscles is dubious in principle. Rationalistic investigation can experience only mathematical relations and the reality of matter can only be viewed as proportion and dimension. We can only understand machines because all their functions can be reconstructed by investigation of the function of their parts. These parts of the world machine first are thought by god and later on produced. The parts of being within Descartes’s thinking are purely dimensional and equal. Behind these qualities of the ultimate parts there is nothing else. They can be differentiated only in their size, geometry and configuration. Every phenomenon in the cosmic universe is a configuration and local movement of these parts. Additionally all living beings function in the same way, purely mechanistically.

Descartes’s strict mechanisation of everything within nature became a broad mainstream world view. The principles of mechanics were adapted to whole physics and as result this kind of physics became the basic science of all empirical research and investigation. A late player was Newton, whose philosophy was founded on mechanistic principles. According to Newton, ultimate particles are created by god as massive particles. From this, the next step was the apodictic mechanism of LaPlace, who stated that every single status within the world and cosmos is a strict effect of the foregoing causes. If there were a mind which could oversee all forces which are existent in nature it would be able to predict every future development out of this knowledge, because everything happens according to strict mechanical laws (the LaPlace demon).

Then came a state of universal determinism: the state of every closed system at a certain moment determines the following development for all time. The whole world as well as the universe is a big machine, which is constituted by an infinite quantity of parts, all of them underlying strict natural laws. With strict rational
thinking nature has to be analysed in minutest detail until all parts of nature are part of scientific knowledge. Then sometimes mechanical nature can be reconstructed completely and even optimised, unlike real nature.

This is also valid for all living beings including humans, especially the human mind. This was a basic conviction also of Dubois-Reymond, one of the main mentors of Sigmund Freud. In the twentieth century, Rudolf Carnap was also convinced that the psychological features of humans are a bundle of physiological mechanistic single processes and should be explained mechanistically.

1.1.3 Organic-Morphological World View

In between these two completely contradictory world views there is a third world view which was worked out by Aristotle and later on by Thomas Aquinas, and has been further developed in the twentieth century by the school of Neo-Thomists like Nikolai Hartman, Aloys Wenzl, Hedwig Konrad-Martius and others. The starting-point of the so-called organic-morphological world view is the theory of levels, which includes a categorisation of the delimitations and differences between these levels. Hartman distinguishes four levels of being: the material, the vital, the psychic and the mental. These levels differ in their stages on the way to perfection which depend on the translation of potentiality into actuality. In the level of the material, the potentiality is dominating, actuality is less, i.e. the real matter of the world behaves according to natural laws, e.g., in the case of nuclear technologies, much more actuality can be processed out of single atoms. In a nuclear chain reaction actuality is nearly indefinite whereas potentiality approaches zero. The higher level integrates the lower one, although the lower one is not dissolved but gets a new function within the higher one. This means reality is constituted by many and ultimate smallest particles which develop in real processual reality into different forms which unite to become such things as bodies of living beings. This organic morphological world view strictly contradicts the monistic-organismic as well as the pluralistic mechanistic world view. The relationships between these levels are determined by a set of laws:

1. Law of autonomy: according to Hartmann, each layer of being is autonomously structured and the genesis of this autonomy cannot be fully derived from the next lower level. The mental level is therefore independent of the psychic level, the psychic of the vital, and the vital of the inorganic. This does not necessarily mean that the mental level lacks the psychic level, the psychic level lacks the vital one and the vital lacks inorganic elements. Rather it emphasises that each of these levels is characterised by features that can be found here and only here. Within this law of autonomy there are two subordinate laws. (a) The law of novelty: in each higher level, features appear which are lacking in the next lower level. These features represent a novelty, something new compared with the lower level. Such new features are neither a logical consequence in the development from the lower to the higher level nor can they be fully derived from the former. (b) The law of modified, recurrent features: the laws of the lower level reappear in the higher level, never vice
versa, but in a modified manner. Specifically, the laws of the lower are structurally and functionally integrated into the higher. For example, the laws of the inorganic level recur in the vital level, but under organisational principles of the vital level, i.e. in a constellation unknown in the inorganic level.

2. Law of dominance: the laws specific to one level do not merely govern that layer. Within the overall organism, every higher level acts on all levels below it, without dismantling or negating them. Humans, for example, possess a vegetative nervous system whose function is largely independent of mental activity. This mental activity, however, can influence the psychic state and, by destabilising it, e.g. in extreme stress situations, have an effect on the vegetative nervous system.

3. Law of dependence: each higher level is neither poised above nor determined by the lower ones, although a certain dependence does exist. The mental level functions on the basis of the psychic, this on the vital, and the vital in turn on inorganic substances. In the case of comatose patients, the vital level and the vital organisation of the inorganic matter comprising the body continue to function, but the psychic and mental levels are silenced.

4. Law of distance: owing to the new, defining quality of a level of being, Nikolai Hartman recognises a ‘metaphysical discontinuity’ rather than actual transitions between these levels. While representatives of approaches based on continuity theories have always postulated such transitions, no actual transitions have been found or convincingly reconstructed in the field of palaeontology. According to this law, nature, and even evolution, progresses in discrete steps.

In contrast with the former two most prominent world views with their ‘all is one’ or ‘all are part’, in this different worldview being is a kind of processual reality with developmental stages from simpler to more complex structures. Also in contrast with the former conception, the occurrence of novelty which did not exist before is a special feature of being and cannot be logically or ontologically deduced from former stages. Movement, development, changeability from the littlest inorganic parts up to the human mind is an inherent potentiality of being and not a mere epiphenomenon or mixture of unchangeable smallest beings. The differences between the organic morphological world view and the monistic-organismic and pluralistic-mechanistic world views are fundamental and unbridgeable.

1.2 Delimitations Against Metaphysics

All schools of philosophy from antiquity and the classical Greek age up until the twentieth century tried to solve the classical problems of antinomy, i.e. (i) the relationship of the whole and its parts and (ii) the (statical) being and the (dynamical) becoming. The short overview of the philosophical conceptions, their tendencies and motifs described a kind of philosophy which was to be strictly avoided by the philosophy of science called logical empiricism (neo-positivism) and later on critical rationalism. The whole dictionary and language game played in these metaphysical languages was a real nightmare for the proponents of the project of ‘exact science’.
They were convinced they could find a language which could both exclude metaphysical language, inexact terms and apodictically-claimed truth and for the future express empirical sensory data unambiguously and definitively.

For logical empiricism metaphysical questions do not have any subject and therefore replace this kind of philosophy by the primacy of empirical scientific knowledge, materialism and naturalism. As we will see later, both the idealistic tradition and its materialistic counterpart and even empirism share classical metaphysical positions such as (i) their claim of being an original philosophy and (ii) the identification of being and thinking. The latter one particularly constructs an inner relationship between thinking and being: as we are thinking, being also functions. The general, the necessary and the supratemporal can be found also in their terms. Empirism and Nominalism identified this self-misunderstanding. They resolved this misunderstanding in a multitude of entities without qualities. Only by the sensory organs of feeling subjects can these entities be mentioned and then be reconstructed within their imaginative apparatus.

Modern empirism wanted to be freed from these metaphysical implications by a substantial and fundamental critique of metaphysics. Therefore the only serious value for science is the rationality of the methods of scientific knowledge, i.e. the formalisable expression of empirical sentences. This is strict objectivism, which restricts itself to a pure observer perspective that confirms its observations by techniques of measurements and subsumes reality in the formalisable depiction of these measurements. Between metaphysics and objectivism there is an unbridgeable gap: what can be found empirically and described as formalisable exists. Outside these criteria everything can be believed but is not the subject of exact sciences. From now on objectivity is the main agenda of natural sciences, subjectivity the subject of human sciences. The interesting and ambitious programme of logical empiricism started as no scientific discipline started before: by a fundamental critique of the sentences with which we describe observations and those with which we construct theories.

This scientific approach was a fundamental shift in the history of philosophy. In the main focus were not the things, the world, the being but conversely the medium in which we describe our opinions, impressions, experiences, the language itself.

1.2.1 Linguistic Turn

To delimitate exact scientific sentences from inexact sentences as they occur in philosophy and theology, the school of logical empirism (Carnap 1931a, 1931b, 1934, 1939, 1956, 1966; Neurath 1932; Gödel 1931, and later on Russell 1940; Tarski 1966) at the beginning of the 1930s tried to construct a formalised language of exact sciences according to the young Ludwig Wittgenstein and the theoretical construction which he outlined in *Tractatus Logico-Philosophicus* (Wittgenstein 1959). With this formalised language of exact sciences it should be possible to outline empirical results of experimental research exactly and without ambiguity. This means that every sentence with which observations are described as well as sentences which are
used to construct theories must fulfill the criterion of formalisability, i.e. they must be expressible as mathematics. Only sentences which fulfill this criterion should be claimed as (termed as) scientific. Sentences which would not be formalisable have to be excluded from science because they are not scientific sentences. By this procedure natural science should be installed as exact science. Because the world functions exclusively according to the laws and principles of physics, this world can be depicted only by sentences of mathematics which are able to express physical reality in a one-to-one manner. Natural laws expressed within the language of mathematics, i.e. formalisable, represent the inner logic of nature. The central part and most important element of language therefore is the syntax, because only by the logical syntactic structure of language is it possible to depict the logical structure of nature. Language as depiction of the natural laws of reality therefore must be formalisable in all its aspects. Because language therefore is seen as a quantifiable set of signs it can be expressed also in binary codes (1/0). Meaning functions therefore are deducible solely from this formal syntactic structure.

Similarly to this model of language, cybernetic system theory and information theory investigate the empirical significance of scientific sentences out of a quantifiable set of signs and, additionally, out of the information transfer of formalised references between a sender and a receiver (sender-receiver narrative). Information-processing systems therefore are quantifiable themselves. Understanding information is possible because of the logical structure of the universal syntax, i.e. by a process which reverses the construction of meaning. Because of this theorem, information theory is also a mathematical theory of language (Shannon and Weaver 1949; Turing 1950). Both constructions are founded on the assumption that reality can be depicted in a one-to-one manner only by formalisable procedures, i.e. formalised sentences. Exact sciences means correspondence of thinking and being. Manfred Eigen adapted these models for biology in the last third of the twentieth century in the description of the genetic code as a language-like structure (Eigen and Winkler 1975).

### 1.2.2 Manfred Eigen’s Adaptation of the Linguistic Turn to Biology

Manfred Eigen compares human language with molecular genetic language explicitly. Both serve as communication mechanisms. The molecular constitution of genes is possible, according to Eigen, because nucleic acids are arranged according

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2 ‘Speech, communication, reading and comprehension on this level mean binding (=recognising) the complementary molecular building blocks (=language symbols) and linking them into a macromolecular ribbon (=text)’ (307).

3 ‘Each language primarily reflects the characteristic features of the respective, underlying communication machinery’ (313).
to the syntax and semantics of this molecular language. Even the amino acid sequences constitute a linguistic system. Through this comparison Manfred Eigen follows the depiction theory of language within the tradition of empiricism, logics, mathematical language theory, cybernetic systems theory and information theory.

The world behaves according to physically determinable natural laws. These natural laws can be expressed only by using the language of mathematics. The formalisable artificial language of mathematics is alone capable of realistically depicting these natural laws. Language in its fundamental sense is language as a formalised sign language. The natural laws are explications of the implicit order of mathematics and nature. Mathematical language depicts this logical order through the logical structure of the linguistic sign system. The essential level of rules of a language therefore is the syntax. Only through the syntax does the logical structure of a language as a depiction of the logical structure of nature come to light. Because both the identity of the logical order of the language in its syntax and the logical order of nature can be expressed in mathematics, this language is quantifiable and can be expressed in binary codes (1/0).

The semantic aspect of language initially comprises an incidentally developed or combined sign sequence, a mixture of characters, which only gain significance in the course of specific selection processes. The linguistic signs are variables whose syntax is subject to the natural laws governing the sign-using brain organ. The brain of humans, for example, is endowed with these variables and combines them to reflect synapse network logics. The variable sign syntax of the brain then must be filled up with experiences of a personal nature and thus constitutes an individualised evaluation scheme.

In messages between communication partners, one side encodes the message in phonetic characters. The receiver must then decode and interpret the message based on empathy and personal experience. Understanding messages shared between sender and receiver is largely possible because the uniform logical form – a universal syntax – lies hidden behind every language.

The function of that organ which syntactically combines the language signs according to its own structure most closely corresponds in Eigen’s opinion to cybernetics, i.e. the theory of information-processing systems (while abstracting the manner of its realisation). Functional units like the central nervous system, brain or even macromolecules consist of a definable, limited number of elements and a

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4 ‘The relative arrangement of the individual genes, the gene map, as well as the syntax and semantics of this molecular language are (…) largely known today’ (207).

5 ‘Although the active center – the actual three-dimensional word correlate of the protein language – comprises no more characters than the number of verbs in spoken language, the protein molecule must unite a total of between one to five hundred chain elements within itself in order to form such an active center, each one of these molecules represents a particular task and one could describe the enzymes as the „verbs‘ of the molecular language‘. (305) (…) All the words of the molecular language are combined to a meaningful text, which can be broken down into sentences‘ (305).

6 ‘…sentence structures, if we disregard the specific peculiarities of the individual languages, exhibit parallels that indicate a universal regularity evidently originating in the organization of the human brain‘ (301).
limited number of relationships between these elements. These systems, along with their description by means of a language, are depictions of a reality, structured by natural laws. Since both the logic of the describing and that of the theory constructing language correspond with the logic of the system, the relationship between these elements of the system can be represented in an abstract, formal and unambiguous manner.

From the perspective of man as a machine, humans clearly represent an optimal model: they fulfil all those preconditions for constructing algorithms that a conventional machine cannot deliver, i.e. criteria for information evaluation based on the real social lifeworld. Humans, and all other biological systems, resemble a learning machine capable of internally producing a syntactically correct depiction of the environment by interacting with this environment, of correcting this depiction through repeated interactions and thus of changing their behaviour according to the environmental circumstances. Such learning systems are able to continuously optimise their adaptability.

The differences between nucleic acid language and human language stem from the continuous developmental processes of biological structures, based on the model of a self-reproducing and self-regulating automaton that functions as realisations of algorithms. This enables the steady optimisation of problem-solving strategies in organisms, eventually leading to the constitution of a central nervous system, a precursor ultimately giving rise to the brain and its enormous storage and information-processing capacity. Language enables the implementation of this evolutionary plan (from the amoeba to Einstein): this medium forms, transforms, stores, expands and combines information.

1.2.3 Deficiencies of Manfred Eigen’s Depiction Theory of Language

Even formal systems are not closed, as Eigen suggests, nor are they principally fully determinable. Furthermore, language is the result of communicative interactions