Chapter 1
Introduction

Abstract Morphogenesis, the general topic of the Lecture Notes, has been applied to language and other cultural media (symbolic forms). An essential input came from René Thom, the French mathematician and Fields Medal winner. The chapter starts by considering the role of morphogenesis in the life sciences and the transition from biological to semiotic morphogenesis (semiogenesis). Further elaborations consider the impact of individuation, the specification of morphogenesis for human populations and individuals, the role of traditions and reflection (ratiogenesis), and, eventually, the relation between morphogenesis (in the sense of Thom 1972) and "semiophysics" (exposed in (Thom in Esquisse d'une sémiophysique: physique aristotélienne et théorie des catastrophes. Interéditions, Paris [English translation: Semiophysics. A Sketch. Addison-Wesley, Boston 1990], 1988 [19]). Parallel to Thom's proposals, the interdisciplinary field of Synergetics, introduced by Herman Haken, has widened the consideration by the consideration of stochastic dynamics, the analysis of cooperative effects between systems, and the complexities of self-organization in nature and culture.

1.1 Morphogenesis and the Science of Life

The most basic biology question concerns the transition from inert matter to life. In this transition, physical laws do not lose their relevance; on the contrary, they are necessary to explain the origin of life. Nevertheless, essential features change dramatically. Physical laws are reversible, and phase transitions are punctual. In contrast, the transitions and bifurcations in the domain of life are irreversible (until death), processes in the organism depend on the ecology of the system, negative entropy (information gain) is possible,[1] and different levels of organization (with specific laws) are eminent. Minor causes and chance effects may decide upon the further

[1] See the concept of anti-entropy that includes not only a gain of order but also its maintenance in Longo and Montévil ([10]: 19f and 254).

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history of a group or even a species (Blount [3] calls this effect “contingency”), convergent evolutions lead to similarities between species, which are not the result of an identical genetic outfit or parallel causal lines. With the advent of theoretical biology, mathematical technics were inspired by their applications in physics, although the underlying mechanisms are different. These differences ask for a modification of the formal tools applied in physics. Although, in the beginning, biological systems (unicellular organisms) may still be accessible to a physicochemical analysis, complex biological systems, specifically the building of life-forms and their differentiation, ask for an independent treatment that respects the differences mentioned above and considers holistic phenomena, e.g., the telic character of wholes and the back-propagation from the whole to its parts. This aspect had already been clear to Kant at the end of the eighteenth century (“organisms are wholes”). Philosophers of the nineteenth century (e.g., Hegel) made clear that the aspect of genesis, of development, is at the heart of biological reasoning. The morphogenetic phenomena are, therefore, crucial for biology. However, are they also vital to psychology, sociology, and semiotics?

In psychology and the cognitive sciences, we must consider a new transition, which at first sight seems to be inside biology. Living beings interact with the ecology and have their inner stability (metabolism). The brain, characteristic of higher animals, is part of the whole organism. Nevertheless, the brain’s functions in perception, communication, and interaction open a field of processes beyond purely biological morphogenesis. Are phenomena like thinking, (self)-consciousness, and symbolic behavior still accessible via the mechanisms found in the organization of organic life? Because of continuity in evolution, we should assume that on one side basic types of organization in cognitive, communicative, and semiotic systems are shared with the organization of primary biotic systems; on the other side, new features can emerge, establishing a kind of autonomy of symbolic systems. In the context of our topic, we must ask: Can we still describe morphogenesis and the stability and regulation of forms of behavior in the framework of theoretical biology? It seems plausible to conjecture a transition similar to the one considered when the physical frame changed into a biological one. As in the former case, some general features will remain relevant, but new phenomena, regularities, and laws should appear.

1.1.1 The Rise of Theoretical Biology and the Role of Morphogenesis

The theoretical treatment of morphogenesis, specifically on mathematical background, goes back to D’Arcy Thompson (1860–1948), who in 1917 published his book *On Growth and Form*. Significant advances were due to Conrad Waddington (1905–1975) and his work in the thirties on “developmental epigenetics" (cf. his book: Organizers & Genes, 1940). René Thom (1923–2002) carried this thread on. He used mathematical results of differential topology (catastrophe theory) to map

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the processes of biological morphogenesis and expanded this view to the human and social sciences (cf. Thom [18]). In the following decades, this program was further substantiated and diversified, mainly using the quickly evolving field of dynamic systems theory (catastrophes, chaos, fractals, stochastic dynamics). Most of the proponents of this endeavor came from mathematics (Thom and Zeeman), physics (Haken), and chemistry (Prigogine). In the eighties, the concepts of autopoiesis and self-organization advocated by the neuroscientist Humberto Maturana (*1928) attracted many biologists and psychologists.

Meanwhile, significant results and theoretical advances have been integrated into the field of the corresponding natural sciences (from physics to the neurosciences). However, applications to the human and social sciences are still controversial and ask for a better empirical and theoretical foundation. If Johann Wolfgang Goethe (1749–1832) considered an embracing discipline "Morphologie überhaupt" (universal morphology) ranging from biology to the arts (literature, visual art, music), this dream seems still to be far off. Intuitively, the creation of forms, their classification, their historical evolution, and the artist's creative act ask for concepts similar to those found in the analysis of living beings. Beyond intuitive creativity, art concerns primarily the emotion, the will, and the rationality of a human being in the creation and appraisal of symbolic forms.

1.1.2 Darwin Revisited

The first effect of Darwinism, responsible for its triumph after almost a century of debates, was that its theory rendered God as an explanatory force of evolution superfluous. As such, it continued the trend established by Condillac, Rousseau, and Herder in the eighteenth century and announced the triumph of physical science at the end of the nineteenth century. Its second impulse was to introduce a space of possible evolutions (variation in Darwin's terms) out of which selection can choose. This space became more concrete with modern genetics, the explanation of mutations, and the deciphering of DNA. In addition, statistical models could model the interaction of mutation and selection. These advances transformed Darwin's incomplete explanation into Neo-Darwinism (the New Synthesis).

A further transformation of Darwinism occurred in the late seventies of the twentieth century and led to new theories called EVO-DEVO (ecological evolutionary developmental biology). In this context, it was possible to revitalize fundamental insights of nineteenth-century biology, i.e., deep homologies that link biological entities separated by hundreds of millions of years, for instance, fruit flies, mice, and humans. The key to these analogies is ancient genes that have been conserved for millions of years and can control the homology of basic morphological "plans" despite huge morphological differences. Homeotic genes, i.e., genes that control the identity and correct order of bodily segments, constitute the "homeobox", i.e., the set of gene segments shared by the homeotic genes (cf. Schering 2001: Chap. 3). Many of the homologies mentioned by René Thom in 1972 between patterns in plants and animals on the one side and humans and human behavior on the other can be related to such ancient genetic programs (morphogens, instructed signals).[2] Our discussion cannot go into the details of Evo–Devo-theories or experimental research in biochemistry. Still, this specification of Darwinian theory demonstrates that the morphological intuitions of René Thom and many predecessors (e.g., Goethe or St. Hilaire) are worth further consideration and do not contradict modern evolutionary biology.

In the case of symbolic forms, this means that although experimental research in genetics cannot bridge the gap between unity and diversity in fruit flies and universality/diversity in language and other symbolic forms, it makes sense to consider two different types of dynamics. First, the dynamics of self-organization start from a homogeneous base situation and arrive at a highly organized end situation. Mathematically, these dynamics refer to Turing's models in the early fifties of the twentieth century.[3] They may explain the rapid growth of diversity but cannot explain the long-lasting stability of species and families of species and their identity. Second, the existence of a developmental genetic toolkit that enables the conservation of old patterns in the midst of growing diversity (cf. Hidalgo et al. [7]). It remains still unclear what the nature of such a toolkit could be that controls the unity and diversity of cultural universals versus the divergence of cultural forms throughout the world. In Chap. 2, we shall argue that the organization of perceptual organs (in humans, particularly sight and hearing) constitutes a kind of "homeobox" for unfolding symbolic forms. A further ancient base is the dynamics of motion and locomotion, as the main Chaps. 3, 4, 5, and 6 will show.

Significant problems with evolutionary explanations remain. First, selection concerns the phenotype (the individual animal, its survival, and the creation of progeny); the transmission of the results to the genotype is less direct than presumed (epigenetic and global physiological factors interfere).[4] Second, the survival and expansion of new variants (based on unpredictable mutations) depend on many ecological and social contexts. Third, some effects may be self-referential as new variants change the survival conditions. This effect can occur *inside* the organism if variants trigger structural reorganizations or *outside* if moving and very active animals change their environment.[5] This effect became clear with humans and, most

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[2] Mechanistic models of morphogenesis insist on the locality of all mechanisms and a reduction to physical and chemical action and reaction based on molecules. As our perspective is clearly "high-level", we do not adopt such a strictly molecular and local strategy. The Nobel prize winner Christiane Nüsslein-Vollhard shows in her book, Nüsslein-Vollhard (2004: 82–101), that basic processes of segmentation and spatial organization encountered in very different classes of animals establish gradients whose interaction and conflict are constitutive for morphogenesis.

[3] "Alan Turing first formulated this theory in 1952 with a 'reaction–diffusion' model describing the interaction of an activator and long-range diffusing inhibitor. Most work has since assumed a molecular basis for self-organization." Bailleul et al. ([2]: Sect. 1.3).

[4] Darwin still accepted a kind of Lamarckian mechanism which transforms individual cognitive and behavioral advances into features of a species.

[5] See also the notion of "ecomorph" introduced by Williams (1972): a "species with the same structural habitat/niche, not necessarily close phyletically, but similar in morphology and behavior." (cited in Blount [3].

dramatically, since the industrial revolution, which led to a new stage, the so-called *Anthropocene*, a world profoundly changed by man (Anthropos). These shortcomings of Darwinism have further consequences for evolutionary psychology, linguistics, and the evolution of human culture because complicated self-organization and self-referential effects occur in highly complex and large systems. Simple Darwinian mechanisms are more transparent and more decisive at the level of molecular evolution (cf. Eigen and Schuster [5]).

In the case of language evolution (cf. Wildgen 2004a), three relatively rapid and vital changes occurred:

(a) The transition from ape-like behavior in australopithecines (3–4 million years (=my) before present (=BP))[6] to Homo ergaster/erectus (ca. two my BP). It doubled cranial capacity, introduced tool use, and led to larger social groups.
(b) The transition from descendants of Homo ergaster in Africa to Homo sapiens finished ca. 300,000 years ago. After a bottleneck around 120,000 BP, this species expanded in and out of Africa (since 100,000, mainly after 70,000 BP). It seems plausible to explain these and further changes by applying morphogenetic principles.[7] In the case of language, this process led from the (hypothetical) protolanguage of Homo erectus to the human language capacity shared by all humans.
(c) Sophisticated cultural innovations appeared with the Neolithic revolution (beginning after the last ice age, i.e., approximately 10,000 BP), the first large and highly organized civilizations in Egypt and Mesopotamia, and the emergence of writing. However, it is not plausible that evolutionary processes affected essential human capacities in this period because the Darwinian mutation and selection mechanisms ask for more extensive time intervals due to mutation rates and the necessary time for the distribution and dominance of selected variants.

The communicative and social capacities of the evolving species (cf. Sect. 1.1.3) expand biological *morphogenesis* to *semiogenesis*. One must also consider *individuation*, which operates in the transition from genotype, the genetic type, to phenotype, the individual body/mind. Individuation contributes to the constitution of social systems like clans, regional associations of social groups, ethnical wholes, and large societies. These dynamics are responsible for the vast diversity of human cultures and symbolic forms. This process is called *ecological* and *social morphogenesis*; it concerns the unfolding of behavioral and cognitive "forms" (Greek *morphḗ*) in individuals and societies, their selection, and stabilization in an ecological context.

[6] BP = before present. "present" refers to a conference in 1955 where this category was created. In the case of historical time, the classical labels BC = before Christ, and AC = after Christ are used. Roughly, BC = BP – 2000.

[7] The last surviving non-human species was the late Neanderthal man in Europe (extinct between 37,000 and 30,000 BP), i.e., before the maximum of the last ice age (25,000 to 20,000 BP).

1.1.3 From Biological Morphogenesis to Semiogenesis

In epigenetic processes and embryology, a structural framing occurs, which limits new genetic variants and the bodily expression of genes, i.e., it shapes the space of possible forms. In the social, cultural, and ecological domain, other morphogenetic processes occur, called *semiogenetic*, insofar as the perception and mental reaction to the environment are a requisite of form-giving and form-transmission (imitation and learning). Cultural transmission replaces or goes parallel to genetic transfer. Semiogenesis redefines the relevant environment, changes the selective forces, and thus indirectly influences the genetic outfit and its epigenetic expression. Two highly relevant transitions after hominization had a major impact on the further development of human symbolic media and languages:

(a) The culture of painted caves in the late Paleolithic is documented between 37,000 and 16,000 BP. A rich corpus of paintings, drawings, sculptures, and abstract (quasi-writing) symbols illustrate this period, which extended over Central and Eastern Europe under the conditions of the last ice age (recently, cave paintings were discovered in Borneo).
(b) The new technologies of farming and cattle breeding led to many cultural innovations, e.g., writing and urbanization. It produced the first large-scale societies in Egypt, Mesopotamia, and the Indus valley (beginning around 5,000 BP = 3,000 BC).

A recent transition to a so-called "morphogenic society" in late modernity is advocated by Archer [1]. Earlier societies were relatively static, as negative feedback to social changes dominated and evinced rapid changes. In morphogenic societies, changes receive positive feedback. At first, innovations in social relations are realized in sub-cultures and social niches. After this experimental stage, some are rapidly generalized to the whole society or even globally. In a morphogenic society, symbolic media will also change rapidly and either lose their relevance and the number of adherents or be diffused exponentially. At the same time, the rhythm of changes increases, followed by a quick change of values. In encounters with people from other groups or newly built networks, the values and norms become unpredictable.

1.2 The Impact of Individuation

The processes of survival and selection operate on the level of the individual. This is clearest in Darwin's favorite example: sexual selection (cf. Darwin 1874). Sexual partners either reject or accept one another, and the transfer of genes is blocked or enabled. This scenario presupposes *individuation* and a *context* (time, place, and the presence of other agents like rivals).

An individual is defined by the natural limits of life (i.e., birth and death) and the forces that sustain his/her life. If life is endangered, appropriate mechanisms exist to recover, repair damages, and avoid death. In this perspective, individuation has an implicit finality: survival under danger and risk. A tribe or family group may disappear if its reproduction rate is too low. Thus, in small and separated groups, a scenario characteristic of Neanderthals, the loss of some younger females may lead the group to extinction; if this often occurs and becomes a trend, the species may be extinct after several generations (particularly, if the overall population is small; it is assumed that the population of Neanderthals did not exceed 10,000 individuals).

By these dynamics, individuation can drive the evolutionary process, i.e., avoid or allow the extinction of a group or, ultimately, a species. Suppose individuals and groups of one species or subspecies share the ecology with others. In that case, their success may enhance the extinction of the other species if the mixture is genetically or behaviorally excluded or rare (dangerous).[8] Individuation is also the bridge for either biological or cultural innovation. For biological innovation, the individual that shows new features due to some biological change must first survive in the environment of individuals without this change and then produce progeny. These conditions decide whether the new capacities of the individual survive and finally change the characteristics of a group or even a species. In the case of cultural innovation, other individuals must perceive it as positive: imitate/learn it to become part of the cultural heritage. In each case, the change must be perceived and evaluated to trigger a new behavior, i.e., the effect relies on semiotic (sign-related) factors. Symbolic behavior evolution is enhanced by individuation processes and by the propagation and socialization of semiotic innovations.

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1.3 Tradigenetic and Ratiogenetic Processes

One can distinguish tradigenetic and ratiogenetic processes (cf. Tembrock [16]). In the first case, sociocultural values, standards, and techniques are transmitted and conserved within a social group (e.g., a family, tribe, or a geographically connected set of tribes); the members of a group establish a tradition as a system of habits. Ratiogenetic processes enhance such events by distinguishing individuals or professional groups for their directive function. These persons may be older adults, priests (shamans), elected chiefs, etc. They incorporate the group's heritage (in their life memory) and can plan and direct specific innovations or dramatic changes that deeply influence a population's fate. Thus, the figure of Moses, who led the people of Israel out of Egypt, the prophets and founders of religion, or significant statesmen (see Alexander, Augustus in antiquity) and their helpers (a small subpart of the society) can rationally move a given society into a specific direction. Since the industrial

[8] Thus, Neanderthal individuals seem to have mixed with individuals of the early Homo sapiens when they met around 100,000 BP. However, a mixture in Europe after 40,000 BP, when Homo sapiens migrated massively into Europe, was rare. It did not prevent the extinction of the Neanderthals (possibly their offspring had health problems and rarely survived).

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revolution (England 1760–1840), the French revolution (1799), and socialism (nineteenth century), technological, scientific, and political innovations have influenced the development of humanity.[9] Insofar as ratiogenetic processes refer to individual minds, i.e., the imagination and planning of individuals, they are part of individuation. In the transmission process, the traces of this origin may disappear because many people have contributed to its elaboration, transmission, and the establishment of new standards.

1.4 Morphogenesis and Mathematics for the Human Sciences

Christopher Zeeman and his disciples (mainly Ian Stewart and Tim Poston) issued a large number of applications ranging from models of heart rhythm, the behavior of dogs (flight/attack), and the dynamics of the human brain to social behavior (cf. Zeeman [23] and Poston and Stewart [15]). Consequently, qualitative dynamics (already sketched by Poincaré, 1874–1912) became an object of general concern. American and Russian mathematicians (Mather, Milnor, Smale, and Arnold) have further advanced the theory of singularities. Still, Thom's primary aim was to unfold further the morphogenetic intuitions he had described in his book *Stabilité structurelle et morphogenèse* (1972). Thom's and Zeeman's proposals have shown that the mathematical results in singularity theory and dynamic systems theory not only have deep historical sources in mathematics but are very promising for future research. Thom took up Aristotle's idea of "genus" (type) and introduced the terms "prégnance" and "saillance" which make up the heart of his "Semiophysics" (cf. Petitot [13], Thom [19], and Wildgen 2010b). Similar developments were at the heart of Hermann Haken's "Synergetics" and the models of the neuroscientist Scott [8], *Dynamic patterns: the self-organization of brain and behavior*). The shared strategy of these groups may be called "From matter to mind", i.e., the theories of the human mind are systematically founded on biological and physical systems theory and focus on the continuity between the natural and the human sciences.

René Thom, the famous mathematician, was indirectly attracted by semiotics and linguistics. At a point in his career as a mathematician,[3] appointed to the Institute of Advanced Research in the Sciences (Institut des Hautes Études Scientifiques) in Paris, he began to reflect on the role of topology and topological dynamics in the fields of biology and the human sciences. In the sixties, Thom exchanged letters with C. H. Waddington, who wrote a preface to Thom's book *Stabilité structurelle et Morphogenèse* (1972). In the foreword to its translation into English (1975), Waddington refers to his book *Organizers and Genes* (1940), where he formulated

[9] They even impacted the earth's climatic and geological state (cf. the exploitation of resources deep underground and in the oceans and changes in the chemical structure of the atmosphere and climate).

some fundamental questions of theoretical biology, to which Thom found a mathematical answer. One problem with biology is that it cannot be explicitly founded on the laws of physics or chemistry. Such a foundation would ask for systems with millions or billions of factors. A topological treatment allows us to formulate the general contours of an explanation. In a later phase (prepared by articles after 1978), Thom wrote his book *Esquisse d'une sémiophysique* (Sketch of a Semiophysics, published in 1988 and translated to English in 1989). Thom tried to link the forces of the morphogenesis of meaning (semiogenesis) to primary magnitudes known from physics, i.e., gravitation and radiation (light). These universal fields embed the living beings and govern their environment (ecology). They are naturally the background of all perceptual and motor processes. In perception, light is at the basis of our visual perception; gravitation underlies human and animal motor processes and the sensation of pressure and weight; the ear registers sound waves, and the diffusion of chemical substances evokes reactions of our taste and smell organs.[10]

As the dynamics of such fields (e.g., light) have been the topics of physics since Newton and wave dynamics the subject of specific mathematical treatments since Maxwell, it was apparent for Thom to postulate a particular field registered and filtered by our sensory organs. He called it "saillance". The psychophysical field selects these effects as the most informative. Thom's program was to extract as much systematic content as possible from the analogy between physical and perceptual fields. Perception is the primary stratum of semiosis, and any perceptually based symbolic structure elaborates it. Although this strategy from physics to semiotics allows for the transfer of many mathematical techniques, there remains a large gap between psychophysics (the level of perception) and linguistics (or cultural semiotics). The term "prégnance" had to fill this gap and explain the transition from perceptual reactions to symbolic forms (culture).[11]

The dichotomy introduced by Thom has a precursor in Aristotelian philosophy. The corresponding notions for this duality are dynamis (δύναμις) or energeia (ἐνέργεια) versus morphe (μορφή) and typos (τύπος). Moreover, Thom refers explicitly to several modern scientific currents which contain a similar dichotomy:

1. In Pavlov's experiments, dogs salivate if presented with meat and "learn" the conditioned reflex of an associated bell (which evokes similar reactions). Here, the concept is used implicitly; the meat and the bell are "salient". The meat is "pregnant" by the biological constitution of the dog, whose body shows a set of automatic reactions, which are thus the content of the presented sign "meat". The

[10] After World War III, digital computers began to dominate the field of models in the life sciences and supplanted analog models. This trend is currently reversed as the digital models approach complexity limits. Analog models that use the resources of natural resources in physics, chemistry, and biology come to the fore. Cf. Dillavou [4].

[11] In linguistics, many responses to Thom's proposals were either simple repetitions or purely meta-theoretical. However, Thom's ideas were rather meant as stimulation for further research (comparable to his conjecture of a classification of unfolding dynamical systems that led to the mathematically elaborated classification theorem of singularity theory). After a phase of vague acceptance, theoretical linguists returned to the fleshpots of structuralism and its phenomenological epistemology. Cf. the comments on catastrophe theory in Piotrowski and Visetti ([14]: 25f).

associated sign "bell ringing" inherits the meaning of the sign "meat", and classical stimulus–response theory postulates that all meanings follow by stimulus conditioning from basic reflexes (elaborated by "operant conditioning," which starts from chance reactions, reinforced by success).

2. Konrad Lorenz observed the process called "Prägung" (imprinting) in birds (e.g., geese). During a short period after they leave the egg, many birds select rather unspecific stimuli in their environment and quickly elaborate on them to form basic concepts like that of a "mother bird". Thus, if Lorenz quickly uttered sounds and the freshly hatched goose registered his presence, he filled the slot of a "mother goose". As soon as this concept was established, he remained the prototype of a "mother goose" for them. Lorenz generalized this observation and postulated so-called "super releasers", i.e., very primitive schemata which only ask for minimal perceptual and neural control. They may even fit better into abstract molds than biologically real entities. In the process of "Prägung", a rich semantic system is developed which could not have been coded genetically.
3. Another biologist, Jakob von Uexküll, proposed a similar concept of "Bedeutungswelt" (meaningful universe). His theoretical biology influenced Cassirer's philosophy of symbolic forms when they were both lecturing in Hamburg. For Uexküll, every animal creates its own "Bedeutungswelt", which depends first on its windows of perception and then on its vital needs. Thus, a tick reacts perceptually to the concentration of butyric acid, typical of warm-blooded animals. The tick drops if this stimulus is received and eventually enters the animal's fur. This minimal semiotic system guarantees survival as the tick feeds on the animal's blood.[9]
4. In psychology, Gibson elaborated the concepts of "prägnante Gestalt" and "Valenz" of his teacher Koffka and called it *affordance*. Any object or process in our environment may have affordances; thus, a chair allows for sitting, a bed for sleeping, etc. Therefore, the whole ecology is meaningful regarding possible actions or events it will enable. As some activities are more frequent or have more value for survival than others, the concept of affordance allows for grades. Maximal affordance would then correspond to "Prägnanz".
5. Cassirer generalized the perceptual/motoric "Prägnanz" to "symbolische Prägnanz" (symbolic pregnancy) as perception is the first level of semiosis (=symbol creation) in his system. One of the criteria of good gestalt was meaningfulness in Gestalt psychology. For Cassirer, symbolic content is the precondition of accurate perception as elements of perceptual input have to be integrated into a system of perceptually based concepts created by the mind. The signs associated with these concepts allow the steady stream of consciousness to halt as soon as something stable catches our attention.
6. The American psychologist David Hebb, whose work has become fundamental for modern neuropsychology (cf. Hebb-assemblies; i.e., networks of neurons with a similar function), discusses different types of instincts and two models. The first model, called monogenetic, assumes one primary force field of biological motivation, which then separates into various subfields like hunger, thirst, sexual

desire, aggression, fear, intellectual curiosity, etc. The second assumes a topology of motivations with different centers (attractors); cf. Hebb ([6], pp. 246–247).

7. William Stern proposed applying the concept of "Prägung" (imprinting) to language acquisition. He recognized a goal-oriented, internally controlled process in language acquisition. Thomae linked this idea with the more general discussion in ethnology and psychoanalysis (Thomae [17], p. 244). Freud's theory of psycho-genital development assumes far-reaching consequences of fundamental processes in early childhood, which fix specific personality traits for a person's whole life. Thomae (ibid.) explains this effect via a kind of "canalization", which directs all further developments.

Summarizing this discussion which has occupied biologists and psychologists for more than one century,[12] one can assume on the one side that all animals have specific windows to their ecology and on the other side that a small set of motivations or vital force fields exist. However, the list of relevant basic types remains an open question. René Thom presupposes the existence of such an essential and elementary set, which shares the feature of structural stability and is independent of specific material contexts. This basic set is subdivided into "salience" and "pregnancy".

To these rather general ideas already found in the discourse of the scientific community, Thom adds two new concepts:

- The salience effect in perception may be linked via psychophysical laws to the dynamics of objective fields in physics and chemistry; i.e., perception refers in its principles to laws in natural science. In Thom's terms, there is an explanatory continuum between objective salience in physics and chemistry and subjective salience in cognition and semiosis.
- The topology of salient objects and events governs the flow of pregnancies via a process called "diffusion de prégnance" (channeling of pregnancy). As in Lorenz's case of "Prägung" (imprinting), the attractor landscape of pregnancy fills with actual or memorized salience effects. In this channeling, the multiple forms of (perceptual) salience are elaborated into rich and context-dependent fields of categorical perception and behavior.

The self-organization of the differentiated pregnancy effects creates a system of meanings and, thus, the prerequisite for a lexicon of perceptual entities. The crucial step concerns the stability and complexity of repeated transfers in channeling pregnancy. The symbolic form is detached from the salient objects it designates, i.e., the reference to the sign object becomes independent from the time and place of the perception of the corresponding entity. This effect has two consequences: What triggers appetite or avoidance, for example, can be broken down into many aspects, in which the types of usefulness or survival relevance differ. For instance, the community can categorize flora and fauna according to edibility, medicinal effects, and instrumental use. The rich encyclopedias for flora and fauna in many collecting and hunting societies show the outcome of this multiple division of what is vital for an

[12] Cf. For further details of this discussion the chapters in Wildgen and Plümacher (2009; in German) and Wildgen and Brandt (2010; in English).

ethnic group. Applied to visual art, the image culture of a community is particularly striking for the artists and their clients in this society and directs their particular attention.

Thom's hypotheses apply mathematical techniques and theorems to solve fundamental problems. Nevertheless, the psychophysical transition calls for applying the laws of physical dynamics, not only the mathematics used in this field. The authors Turvey, Kugler, Kelso, and others (cf. Kelso [8]) have elaborated on this thought. For instance, the diffusion of pregnancy may correspond to fluid dynamics and models of growth in space and time.

References

1. Archer, M.S. (ed): Late Modernity: Trajectories Towards Morphogenic Society [Social morphogenesis, volume II]. Cham, Springer (2014)
2. Bailleul, R., Manceau, M. , Touboul, J.: A "numerical evo-devo" synthesis for the identification of pattern-forming factors. Cells **9**(8) (2020). Download PMC7463486
3. Blount, Z.D.: A case study in evolutionary contingency. Stud. Hist. Philos. Biol. Biomed. Sci. **58**, 82–92 (2016)
4. Dillavou, S. et al.: Demonstration of Decentralized, Physics-driven Learning. ArXiv: 2108.00275 (2022)
5. Eigen, M., Schuster, P.: The Hypercycle: A Principle of Natural Self-organization. Springer, Berlin (1979)
6. Hebb, D.O.: A Textbook of Psychology (new edition 1966). Saunders, Philadelphia (1959/1966).
7. Hidalgo, M., Curantz, C., Manceau, M.: A conserved paint box underlies color pattern diversity in Estrildid finches. Biology, 20 February 2021. https://www.semanticscholar.org/paper/A-conserved-paint-box-underlies-color-pattern-in-Hidalgo-Curantz/51726ba6a25ccef20a9d14d57e042bb253f936c5 (2021)
8. Kelso, J.A.S.: Dynamic patterns. In: The Self-organization of Brain and Behavior MIT Press, Cambridge (Mass) (1995)
9. Kosslyn, S.M.: Image and Mid. Harvard U.P, Cambridge MA (1980)
10. Longo, G., Montévil, M.: Perspectives on Organisms. Biological Time, Symmetries and Singularities (series: Lecture Notes in Morphogenesis). Springer, Heidelberg (2014)
11. Maturana, H., Varela, F.J.: Autopoiesis and Cognition: The Realization of the Living. D. Reidel Publishing Company, Dordrecht (1980)
12. Nüsslein-Vollard, Ch.: Das Werden des Lebens. Wie Gene die Entwicklung steuern. Beck, München
13. Petitot, J.: Physique du sens. De la théorie des singularités aux structures sémio-narratives. Éditions du CNRS, Paris (1992)
14. Piotrowski, D., Visetti, Y.M.: The game of complexity and linguistic theorization. In: La Mantia, F., Licata, I., Percoti, P. (eds.) Language in Complexity. The Emerging Meaning. Springer (2017)
15. Poston, T., Stewart, I.: Catastrophe Theory and its Applications. Pitman, Boston (1978)
16. Tembrock, G.: Ökosemiose. In: Posner, R., Robering, K., Sebeok, T.A. (eds.) A Handbook on the Sign-theoretical Foundation of Nature and Culture, pp. 571–591. de Gruyter, Berlin (2004)
17. Thomae, H.: Entwicklung und Prägung. In: Thomae, H. (ed.) Entwicklungspsychologie. Handbuch der Psychologie in 12 Bd, pp. 240–311. Hogrefe, Göttingen (1972)
18. Thom, R.: Stabilité structurelle et morphogenèse, Interéditions, Paris (English translation: Structural stability and morphogenesis. Benjamin, Reading, 1975) (1972)

19. Thom, R.: Esquisse d'une sémiophysique: physique aristotélienne et théorie des catastrophes. Interéditions, Paris [English translation: Semiophysics. A Sketch. Addison-Wesley, Boston 1990] (1988)
20. Waddington, C.H.: Organisers and Genes. Cambridge University Press, Cambridge (1940)
21. Waddington, C.H.: The character of biological form. In: Whyte, L.L. (ed.) Aspects of Form: A Symposium on Form in Nature and Art (1968)
22. Wildgen, W.: Thom's theory of "saillance" and "prégnance" and modern evolutionary linguistics. In: Wildgen, W., Brandt P.Aa. (eds.) Semiosis and Catastrophes. René Thom's Semiotic Heritage, pp. 79–100. Lang, Bern (2010)
23. Zeeman, Ch.: Catastrophe Theory. Selected Papers 1972–1977. Addison-Wesley. Cambridge (Mass) (1977)

Author Queries

Chapter 1

Query Refs.	Details Required	Author's response
AQ1	References Darwin (1874), Schering (2001), Williams (1972), Wildgen (2004a, 2010b), Wildgen and Plümacher (2009), Wildgen and Brandt (2010) and Thom (1972) are cited in the text but not provided in the reference list. Please provide the respective references in the list or delete these citations.	
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