

Lecture Notes in Morphogenesis
Series Editor: Alessandro Sarti

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Clément Morier *Editors*

The Relevance of René Thom

The Morphological Dimension in Today's
Sciences

 Springer

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Lecture Notes in Morphogenesis is an interdisciplinary book series which aims to face the questions of emergence, individuation and becoming of forms from several different points of view: those of pure and applied mathematics, of computational algorithms, of biology, of neurophysiology, of cognitive and social structures. The set of questions above concerns all the manifestations of Being, all the manifestations of Life. At the heart of contemporary embryogenesis lies an essential question: How can form emerge from the constant, chaotic flow? How can a sequence of purely informational elements—an a-signifying combination of chemical substances organized in the DNA molecule—evolve into the highly complex and structured forms of the living organism? A similar question can be asked when we deal with the morphogenesis of vision in neural systems and with the creation of evolving synthetic images, since digital technology makes possible the simulation of emergent processes both of living bodies and of visual forms. Finally the very idea that abstract structures of meaning could be captured in terms of morphodynamic evolution opens the door to new models of semiolinguistics, semiotic morphodynamics, and cognitive grammars. An entire heritage of ideas and concepts has to be reconsidered in order to face new and challenging problems: the theoretical framework opened by Goethe with the introduction of the word “Morphogenesis” is developed by D’Arcy Thompson in “On Growth and Form”, it is reorganized with new theoretical insights by the classical structuralism of Levi-Strauss and formalized by the dynamical structuralism of René Thom. The introduction of the post-structuralists ideas of individuation (in Gilbert Simondon and Gilles Deleuze) and plasticity of structures builds a bridge to contemporary problems of morphogenesis at a physical, biological, social and transindividual level. The objective of this book series is to provide suitable theoretical and practical tools for describing evolutionary phenomena at the level of Free boundary problems in Mathematics, Embryogenesis, Image Evolution in Visual Perception, Visual Models of Morphogenesis, Neuromathematics, Autonomy and Self-Organization, Morphogenetic Emergence and Individuation, Theoretical Biology, Cognitive Morphodynamics, Cities Evolution, Semiotics, Subjectivation processes, Social movements as well as new frontiers of Aesthetics. To submit a proposal or request further information, please use the PDF Proposal Form or contact directly: *Dr. Thomas Ditzinger* (thomas.ditzinger@springer.com)

Isabel Marcos · Clément Morier
Editors

The Relevance of René Thom

The Morphological Dimension in
Today's Sciences

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ISSN 2195-1934

ISSN 2195-1942 (electronic)

Lecture Notes in Morphogenesis

ISBN 978-3-031-54981-6

ISBN 978-3-031-54982-3 (eBook)

<https://doi.org/10.1007/978-3-031-54982-3>

This work has been financed by national funds through FCT—Fundação para a Ciência e Tecnologia I.P.—within the framework of the R&D Unit Centre for Philosophy of Science of the University of Lisbon (CFCUL), a strategic project with the FCT IP. Reference: UIDB 00678/2020 and UIDP/00678/2020.

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*In memory of our professors: René Thom,
Per Aage Brandt, and Jacques Viret*

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Chapter 1

What if Science Thought? The Relevance of René Thom or Introducing Topology into Today's Sciences



Clément Morier and Isabel Marcos

1.1 The Relevance of René Thom: A Morphological Look at Neo-Liberal and Logico-Combinatorial Formalism

It is also the reason why one gear in the watch does not produce another; still less does one watch produce other watches, [by] using (and organizing) other matter for this [production]. It is also the reason why if parts are removed from the watch, it does not replace them on its own; nor, if parts were missing from it when it was first built, does it compensate for this [lack] by having the other parts help out, let alone repair itself on its own when out of order: yet all of this we can expect organized nature to do. Hence an organized being is not a mere machine. For a machine has only motive force. But an organized being has within it formative force, and a formative force that this being imparts to the kinds of matter that lack it (thereby organizing them). This force is therefore a formative force that propagates itself—a force that a mere ability [of one thing] to move [another] (i.e., mechanism) cannot explain.

Kant, *Critique of Judgment*, § 65 [7]

There was once Someone who could watch the same show [...]

sometimes as a painter would have looked at it, and sometimes as a naturalist;

sometimes like a physicist, and other times like a poet;

and none of these looks were superficial

Paul Valéry, Preface to the Notebooks of Leonardo da Vinci [3]

This work was funded by national funds through FCT—Fundação para a Ciência e a Tecnologia, I.P., within the scope of the R&D Unit Center for Philosophy of Sciences of the University of Lisbon (CFCUL), a strategic project with references FCT I.P. UIDB/00678/2020 and UIDP/00678/2020.

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“To Predict is not to Explain”. Such was the warning of one of 20th-century France’s major thinkers, whose legacy is becoming increasingly inaudible in today’s scientific community: René Thom (Fields Medal 1958). To predict, or the ambition of predictability, requires the (potentially infinite) reduction of the forms of nature into discontinuous, quantifiable elements: primarily, so as to enable the subsequent control of their interactions, within a space, according to a mathematical law.

While this logical, combinatorial and quantitative reduction has triumphed in the sciences since the revolution jointly initiated by Descartes and Galileo, it is now extending its reach into contemporary society.

In economics, Marx’s deciphering of “Capital” transforms any qualitative form, object or human, into a simple quantity of money, whose speed of propagation on a market generates a tendentially infinite surplus value.

In the way they operate, political societies no longer know how not to define themselves according to an unconscious model of a “market society”, linking by law discontinuous elements (individuals) who are equally free, and oriented by economic interests, arranged simply by means of “governance” [5].

This is to say nothing of the extension, into all spheres of social life, of computer control, heir to Cartesian metaphysics, or the reduction of all discourse, speech and practice to undifferentiated quantities of information whose propagation and permutation becomes unlimited by means of networking. Even anthropological and sociological disciplines are endangered by the epistemology of networks, emergences and neuronal combinatorics instead of any human-social specificity [9].

Against such a fiery backdrop, we would like to propose another way of looking at things, one that apprehends forms and restores to natural morphologies the sensitivity of their deployment, when they enter into metamorphosis. A critical view, then, of the neo-liberal reductionist flattening that is spreading through the forms of contemporary rationality. In contrast, a rationalism of forms, of their dynamic of transformation, supported by a vibrant geometry (topology), constitutes an available corpus that restores unity to reality, and avoids its disintegration under a simple shower of atoms [10].

1.2 The Relevance of René Thom: A Shift in Philosophical Perspective

In the History of Ideas, the notion behind the Thomian corpus—carried out from topology, precisely on the basis of the scientific achievements of modernity, and not from a Husserlian “epoché” of natural objectivity [6]—constitutes a rediscovery of the *morphological unthinking* of modern reason, rooted in Aristotle’s natural philosophy—in a physics of *ousia* (substance) or “semiophysics”, and not in the phenomenological experiences of consciousness.

Thom’s scientific discoveries obviously accompanied the phenomenological rehabilitation of sensitive morphologies, but his fruitfulness lay in the production of

an explanation and a generativity, by means of the “folding” of space. By integrating into physical objectivity itself the topological and dynamic principles of its phenomenalization—the forms of which could only be apprehended, *de jure*, on the subjective-relative plane for the idealism of mathematical physics, since the Cartesian rupture—Thom joins directly the Notebooks of Leonardo da Vinci, and, with him, the tradition of European Humanism...

By listening to René Thom’s lessons, followed by several schools of linguistics, semiotics and theoretical biology, the phenomenalization of physical objectivity can be treated as a new type of natural phenomenon. The task then becomes to integrate into the objectivity of forms the principles of their phenomenalization that carry the layer, or the strata, of meaning.

1.3 The Relevance of René Thom: An Issue About Rationality in Modernity

This book is based on the scientific results of the “Actualité de René Thom” project (2017–2023 (see also [8])). Through interventions—on the use of morphological modelling—or philosophical and epistemological discussions—on the status of René Thom’s discoveries—this project has brought to light issues in the history of ideas, around an *aporia*, which is the subject of incessant doctrinal conflicts, throughout scientific modernity:

- Either this modern rationality wants to “rehabilitate” the ancient knowledge of quality, stemming from Aristotelianism—*substances* or *forma substantialis*, interacting with *substrates*, and phenomenalized in natural forms, according to a *realism* of efficient causality. This intellectual arc, from Aristotle to Thom’s work, runs through such thinking that of Thomas Aquinas, summoned in the line of Leibniz¹ [14], Goethe, Geoffroy St-Hilaire, D’Arcy Thompson (who began translating the biological works of Aristotle in 1910), A. Turing and C. Waddington;
- Or that mathematical physics—in its fight against the occult qualities so decried by Descartes—proposes to serialize every state of matter in a space of discontinuous points, whose temporal consecution we control, by means of the formalism of a new mathesis. The study of forms would have to give way to the mathematizable legalization of discontinuous entities, offering calculability and predictability by means of functions.

Amid this, the scientific results of the “Actualité de René Thom” project rehabilitate the value, for today’s sciences, of a morphological unthought, in relation

¹ See his letter to Des Bosses, dated February 2, 1706: “[...] Therefore, in addition to figure, size and movement, we must admit forms by means of which the difference in appearances arises in matter, forms that can only be intelligibly sought, it seems to me, from *entelechieis*.” (Frémont [4], p. 85, our translation).

to a rationality built on the idealism of mathematical physics—an idealism that is even accompanied by epistemic locks, which ultimately “foreclose” this unthought, within the great conceptual systems of modernity, such as Kant or Husserl [13].

Many of the results, materializing this morphodynamic rationality at work, construct a history of ideas far removed from a continuous and cumulative development of scientific rationality, based solely on the principle of (efficient) causality. What is to be made of the principle of “structural stability” as a principle of sufficient reason, at least as a foundation for the scientific community? To answer this question is to reposition at its heart the question of the qualitative stability of forms, and that of stable forms of transformation, as integral parts of “reason” in modernity.

This book is part of this modern rationality, morphologically rethought. It does so in two ways: firstly, through its context of enunciation, that of the physico-mathematical formalization of morphological objectivity, within the scientific models of the 20th century; secondly, through René Thom’s connection to the Aristotelian doctrine of forms, and to the Aristotelian formula that seems decisive, in Thom’s eyes: *è entelechia chorizei*, the act separates. An astonishing insight into the properties of discontinuities “bursting” into a substrate space, resulting in a symmetry-breaking effect, that is as *morphogenic* as it is intrinsically *semiotic*. Homeomeric tissue becomes anhomomeric—formalizes Aristotle, as a biologist—and gives rise to morphogenetic differentiation—recalls Thom, as a topologist...

1.4 The Relevance of René Thom: The Challenges of His Thesis of “Involutioned” Meaning in *Phusis* [11]

Physics legalizes phenomena by dealing with laws. The determinism of post-Galilean mechanics, expressed mathematically, substitutes a “generative *logos*” for an explanation by propagation of efficient causality. The geometrization of physical theories trivializes phenomena, reducing their being to a change in spatial arrangement, or to the operativity of groups. The result is an idealist derealization of physical objectivity, or *phusis*. Yet one of the great scientific adventures of the last century was the *Morphological Turn*, which renewed natural philosophy. This is an opportunity to make science rethink, against Heidegger’s 1952 formula, through a demand for scientific intelligibility, which is not separated from appearance, nor from a linguistic description of the world [15].

In his mathematical and philosophical prowess, Thom strove to interpret Aristotle as closely as possible to the corpus. As Thom celebrates his centenary (1923–2023), we would like to pay tribute to him, by briefly reviewing three entries from Aristotle’s corpus, which show Thom’s vision of morphological relevance to the sciences of his time... and by extensions, of our time.

1. **“The limit is also the formal substance of each thing and its quiddity”**—**Metaphysics, Δ 17, 1022a** [2]: Thom addresses the morphological moment at work in Aristotle, through the concept of “limit”, which decides how a form

sends itself into its substrate. Thom's mathematical genius—which intervenes through a peripheral knowledge, topology, a priori far from the issues structuring the history of philosophy—exposes the dynamic modalities by which, precisely, a form is bordered and folded while its contours evolve in space. The foundation of his topological knowledge lies in the singularity, the organizing point of “catastrophe” that emerges abruptly, through a continuous deformation of the substrate. This differentiation, which is morphogenetic, operates through a system of boundaries that organizes the substrate, limits it and breaks down its homogeneity.

2. **“È entéléchia chôrizei”, the act separates—Metaphysics, Z 13, 1039a:** Aristotle's proposition guides Thom's neo-Aristotelian epistemology. It is the subject of a specific treatment in his *Semiophysics* ([15], p. 155, p. 227; [15]). Contrary to what phenomenological epistemology assumes, the foundation is not the experience of consciousness, organized as a transcendental system, but the boundary, the catastrophe that divides spaces. The structuring irruption of the finite through morphological differentiation would be the primary condition of all form, phenomenologically perceptible and linguistically describable [12]. “è entéléchéia chôrizei”, the act of separating, becomes the starting point of a new reading of Aristotle for Thom, valid in modernity: a difference in continuity produces an event of separation, and every morphologically structured substrate derives from this, by deploying the organizational germs of algebraic topology patterns.
3. **“Nature is always in a substrate”—Physics, II, 1, 192b-193a [1]:** Accused of Pythagorean or even Platonic formalism, the sensitivity of Thom's discoveries was to apprehend, not so much the mathematical organization of reality, but rather movement and life, not reducible to logical-combinatorial formalisms, notably present in the computer metaphor of the genetic “programme”.² For Thom, Aristotle's originality lies in having imposed a new reality at the centre of natural events, which he calls substance (*ousia*), a separable entity closed in on itself, that we can refer to as “*tode ti choriston*”. Now, its core, its power of underlying, which makes it not a Pythagorean point or plane, is its substrate (*hypokeimeinon*). Thom understands form in terms of its engagement within a substrate. Thomian morphogeneses do not result from ideal systems, otherwise they would fall victim to a Pythagoreanism incapable of supporting life. He sees forms as a set of qualitative singularities *within* a substrate, never independent of the energetic field—or the dynamical system (of Gradient)—in which these singularities appear.

² In Book 14, N, of the *Metaphysics*, Aristotle discusses the incoherence of a mathematics of numbers to apprehend life and generation in nature. We find extensions of these positions in D'Arcy Thompson, with his theory of Forms, in Goethe, a morphologist attentive to the quarrel between Cuvier and St-Hilaire, and in Leibniz, with his rehabilitation of *forma substantialis*.

1.5 The Relevance of René Thom: A Plurality of Morphological Perspectives Engaged in Their Disciplines

This book is the fruit of collaboration between researchers working on a common platform. It is a collective work, based on a single morphological theme, which aims to capture all the relevance of René Thom's thinking. For each discipline represented here, this morphological theme is approached according to specific, albeit congruent, issues... Here are the main ideas behind the works presented here.

One of the two co-authors of this presentation, **Clément Morier**, demonstrates the importance of René Thom by putting his dynamic model to work, through a dialogue with the philosopher Gilbert Simondon. Far from being relegated to the dustbin of the History of Science, the “morphologies of processes” of catastrophe theory have a specifically innovative aspect: they intrinsically take charge of the reality of movement, the reality of the “time” parameter insofar as it is a change of state and a transformation of form. By studying the morphology known as “swallowtail morphology”, and according to the extensions discerned by Thom's last pupil, Jacques Viret (1943–2018)—one of our mentors—the form of an evolutionary process appears topologically. At a time when substantialist and relationalist ontology are at odds, and since *metamorphosis* must be considered in today's sciences, there is nothing that cannot be attempted, not even a reading that draws on the vocabulary of Simondon—a thinker of individuation according to movement—to explain the deployment of René Thom's figures—as the guardian of a pantheon of archetypal morphological deformations.

“We semantize physical space” is the injunction that governed the work of our late friend and other mentor, Pr. **Per Aage Brandt** (1944–2021). His research in semiotics, in particular, demonstrates the relevance of René Thom's morphological thinking. It deconstructs semiotic acts, showing that they function according to a logic of “places”, which organize lived spaces, and are thus invested with meaning. His research programme led to what he called a “pheno-physics”, after the expression “semiophysics” used by René Thom, or that of “physics of meaning”, put forward by our other friend and mentor, Pr. Jean Petitot.

By semantizing, we valorize or repel, we thus invest lived space with repulsive borders or “guardian” edges. Places, that are thus energized, welcome things... and the displacement from their initial places creates narratives of meaning. Brandt gives us the keys to the topological “formants” that establish this *sense-making—mise en sens*—of lived reality, which is a real *morphological shaping—mise en forme*—of the world...

The next study is proposed by **Wolfgang Wildgen**, a long-standing companion of a linguistic science apprehended according to morphological and dynamic “archetypes”. Indeed, the author himself belongs to this heritage of formalizing signs and language processes, which is rooted in an entire history of science, the main moments and turning points of which are recounted here. The topicality here lies in the practice of “interdisciplinary research enterprises based on modern mathematics

and using the methodological and empirical standards of the natural sciences”, to apprehend semantic spaces in general, and linguistic spaces in particular. So, is there an underlying morphology, an archetypal process, that could organize meaningful interactions as diverse as “Charles eats soup, Albert tells a story, Berthe calculates the result”? W. Wildgen’s challenge is to plunge us into the heart of a topological and dynamic formalization of such language patterns, even proposing to extend this understanding in terms of dynamic figures to visual and musical signs, bringing René Thom’s thinking up to date. Thus, the fundamental activity of the scientist consists in “finding the relevant categories that enable him to grasp the phenomena in his field of observation”. So, Thom was not just a mathematician...

The questioning of the relevance of Thom’s theses then continues in the fields of geography and urban science: work on the morphogenesis of cities has given rise to uses of René Thom’s thinking, while notions dear to the topologist such as deployment or attractors also raise important questions in the discipline of geography, where *space* and *form* are structuring concepts. However, polysemy should not be misleading, and **Olivier Bonin** sets out to establish operative distinctions, to reflect on the expectations of such tools and concepts, before proposing two models applied to urban form, identifying typical parameters and deformations. In this respect, he points out that “the immense enthusiasm for catastrophe theory has given way to a certain scepticism, which has probably prevented a methodical search for applications in certain disciplines such as geography.” In his study, he draws on Thom’s topological tools, Gilles Ritchot’s concepts of structural geography and even George Dumezil’s trifunctionality, to help identify several “typical” urban deployments, between which boundaries correspond to changes in urban morphology.

When the book “Morphogenèse de Paris” was published by G. Desmarais, almost 30 years ago, Jean Petitot did not shrink from the significance of such a study, which goes to the root of the discipline of geography: “But its importance to the understanding of the geographical essence of human settlement is such that it merits attention and consideration”. Under the active constraint of a geometry of positions, the genesis of the morphological structures of the human-social settlement might spatialize anthropological-symbolic values, whose list of organizing singularities could, with an adequate axiomatic, be inventoried, in order to study their dynamic profile...

However, from the 1990s to the 2010s, the directions actually taken by French-speaking geographical research were unambiguous, according to **Jean-Paul Hubert**: “ideas about the autonomy of forms as theoretical objects (with geometric properties that have a concrete effect on geographical space by overdetermining the mechanisms at work) were consigned to oblivion.” Hence the need for Hubert—and this is the whole point of the study he presents—to take stock, 30 years on, of the conceptual motifs, theoretical devices and spin-offs produced in the field of urban form theory, and their modelling—Thom’s approach here being perfectly capable of being complemented and/or renewed by others, such as Turing, in particular, insofar as not only “any occupation of space excludes all other occupancies and therefore creates discontinuities”, as J-P. Hubert reminds us, but also because urban settlements contain

“enabling morphogeneses” that self-catalyze through slow and fast dynamics. This is an area of current research that looks set to continue.

The succeeding study marks a transition to the next Part of this book. Through a dialogue between two disciplines, psychoanalysis and semiotics—semiotics being considered here from René Thom’s point of view, i.e., dynamically and topologically—**Carlos Farate and Isabel Marcos** propose a co-authored, eminently morphological study. For, this study chooses as the conceptual driving force behind this interdisciplinary dialogue, the notion of *boundaries*. For obvious reasons, since it is by limits that an entity is bordered and its forms can evolve in space. Its morphogenesis, strictly speaking, takes place according to a *system of boundaries*, where differentiations, both structural and functional, operate through a system of *thresholds*. This system of thresholds enables entities to organize themselves on different hierarchical levels, each level having its own stability and points of bifurcation. Here, I. Marcos and C. Farate study the morphogenesis of the structuring boundaries of a territory, based on an analysis of the urban territory, but also of the psychic territory of a human being. The two “territories”—city and psyche—respond to each other in their deployment, providing an “original experience of the limit”, as Walter Benjamin might put it.

Boundaries, demarcations, enclaves and thresholds organize the viewpoint of the two researchers, enabling them to carry out a topography of sensitive zones, where singularities emerge and organize the topology of urban or psychic functioning, caught up in systems of attraction and repulsion.

The imaginary of rejection that permeates the urban fabric, and the experience of psychic trauma in an individual, are both linked in an intersubjective relationship “between inhabited territory and the subject that inhabits it”. Psychoanalysis and urban semiotics are thus rethought, thanks to an analysis of morphogenetic fields. This is why the two authors attempt to sketch out the contours of what they call territorial psychoanalysis, based on a list of key notions such as *morphogenetic gradient*, *vacuum*, *frontier*, as well as *pregnance* and *salience*. In this sense, the Form is indeed independent of its substrate...

As a result, this book—the fruit of collective research into René Thom’s thought, his topology and the epistemological and philosophical consequences of his work—could not completely leave out biology, understood here in the broadest sense of the term, i.e., everything that involves living organisms and is part of evolution. In this sense, the next part had to address such fruitful questions as the uses of modelling in biology; to explore the epistemology of certain concepts, such as the “epigenetic landscape”; while the third part also had to include in its wake topical dialogues in the fields of medicine and psychology—that of both Freud and Jung.

This is why Thom’s relevance and the extensions of catastrophe theory thoroughly question the notion of “archetype”, a complex notion if ever there was one. Much has been said about this notion, which is mainly deployed in the field of Carl Gustav Jung’s analytical psychology: could it be that Thom and Jung—had they been able to talk together—would have discussed their uses of this term, their convergences and divergences, but also the possibility, thanks to the former, of topologically representing dynamic and energetic reality, the effectivity of the archetype, in the psychic

evolution that the latter uncovered? This is the challenge that occupied Professor and general practitioner **Jacques Viret**, one of Thom's last pupils, for many years, as he provided extensive extensions to catastrophe theory, making it accessible and revealing the evolutionary continuity that lies at its heart. It is up to the reader to judge whether he has succeeded...

The next study, which pursues Freudian psychoanalysis, is this time situated as much on the epistemological level as on the actual empirical level of the course of therapy: its author, **Benoît Virole** examines the possibilities for catastrophe theory to become a concrete aid for an analyst in a session, understood as including the specificity of a clinical relationship—an intersubjective relationship, tied up with the patient's psyche in a transference relationship', in which the ego passes through varied emotional states, possibly metastable, sometimes on the verge of very critical zones... "As close as possible to the catastrophic singularity, there is a reactive sensitivity that can induce a bifurcation. One could then imagine the art of analytic interpretation as being that of detecting these critical zones, perhaps by intimate resonance between the mental attractors of the analyst and those of his patient." However, this is not the only relevance that the Theory of René Thom offers to psychoanalysis: Thom has shown that actantial schemas exist beneath all subjective representations, organizing stable interactions—*linguistically describable and phenomenologically perceptible*, to use J. Petitot's expression—between the actants/attractors of the process. Now, B. Virole launches the following conjecture, which deserves particular attention as it is so pregnant with future developments: "one could conjecture that the whole of the development of the libido follows the unfolding of a multidimensional aggregative catastrophe of which the stages (oral, anal and phallic) would only be local sections and of which one would have knowledge by their indexical traces, and precisely by the inscriptions of their agent schemes in the analytic material." The symbolic productions of the unconscious would then be part of a *Morphogenesis of the Psyche* whose unfolding we could understand, filled with episodes of regression, surge and turbulence...

This book goes on to highlight the impact of Thom's ideas on the question of modelling in biology. This study is by a specialist in morphogenesis and complexity in biology, Prof. **Jacques Demongeot**, a friend and supporter of René Thom, for whom he was one of the key relays for the application of his ideas and tools in the field of theoretical biology, a field that J. Demongeot notably helped to establish and considerably expand within the scientific community of his time... For him, Thom "traced scientific leads that we faithfully followed and which turned out to be in fact real programmes." This is true, for example, for the notion of an "attractor", which, even though it had already been potentially developed by Thom, became an axial notion for studying the processes of morphogenesis and regulation in biology. J. Demongeot clarifies and illustrates this concept to show its impact on the study of stabilization mechanisms in living organisms subject to disturbance. Going back to Buffon, the notion of the attractor would even irrigate the ideas of Lamarck and Claude Bernard, emphasizes Demongeot—without even mentioning the famous 1830 controversy between Cuvier and St-Hilaire about the unity of plan

and composition in the animal kingdom, which Goethe followed closely, passionately, and whose reactivation seemed essential to Thom for thinking out a “theoretical” biology, based on his discoveries in topology. Demongeot has promulgated these tools, and the concepts they contain. In this way, he enables us to look back at what is at stake in modelling, in the study of tree growth, for example, or the growth of embryos... “The history of biological modelling shows that, for 250 years, concepts have preceded equations, and that simulations have only confirmed experimental observations, themselves sometimes preceded by rational speculations.” By recalling the memory and the work of his friend Jacques Viret, J. Demongeot concludes: “to model the biological or psychological nature, in an almost identical approach, constitutes, since the Age of Enlightenment, the heart of scientific thought.”

The next study takes us into a more specific biological field, medicine. As a neurologist, **Pierre Bounolleau** illustrates the importance of Thom’s thinking through examples drawn from both “scientific” medicine—which is institutional, causalist, mechanistic and deterministic—and “traditional” medicine, which is diverse but centuries older. Our author restores the scope of so-called “morphodynamic” models (Petitot), i.e. those designed to explain the dynamic processes of morpho-*genesis*—that genesis of structural patterns, based on the sudden appearance of discontinuities, of “singularities”, within an underlying progressive and continuous development; these singularities constitute organizing “germs” that initiate a deployment, i.e., once again, the development of a structurally stable—*robust*—evolving process... This type of reflection constitutes an “entire programme” in medicine, where the “constraints of physiological complexity” reign. “The tradition of mathematical formalization is historically limited there” confides P. Bounolleau. This field thus enables us to test the potential of morphodynamic models, because, according to our author, medical progress has come up against “the insurmountable difficulties of modelling for complex phenomena such as cognition and language. In fact, the physical matter of such complex phenomena is neither sensorially observable nor empirically accessible.” Thus, through transdisciplinarity, traditional medicine—which could be illustrated by Lévi-Strauss’s accounts of cures and the *symbolic efficacy* of certain ancestral practices—and scientific medicine—through the use of connectionist models of cognitive neuroscience, for example—will be able to reconnect... and Thom’s relevance will then consist in playing such a *mediating* role!

The exploration of Thom’s special relationship with biology continues with a plunge into the history of science and the epistemology of concepts proposed by **Sara Franceschelli**. This constitutes an incursion into the heart of reciprocal influences and borrowings, as well as the ways in which the works of each were received, between Waddington, Thom, Delbrück and Turing—not forgetting the “obligatory” passage via D’Arcy Thompson’s masterpiece... Let no one ignorant of *On Growth and Form* enter here! For S. Franceschelli, understanding the epistemological context in which the concept of “structural stability” was applied to the field of biology, enables us to grasp the ways in which decisive notions such as “chreods”, “epigenetic landscape” and the “canalization” of a dynamical system have been constructed. For Thom and Waddington, they determine the way we formally conceive the morphogenesis of

living organisms, by grasping the internal physics of the process at play and its deployment, “channelled” towards an attractor.

Structural stability is the “conceptual tool”, as S. Franceschelli puts it, which enabled Thom to renew the questioning of theoretical biology. In fact, so-called “degenerate” singularities contain information—particularly structural information, which can give rise to functional potential—that can be “generated”, precisely, by lifting this initial “degeneracy”, using certain parameters of which Thom produced a finite list. These parameters become active in the topological-dynamic functioning of catastrophe theory’s figures. These parameters “set in motion” the initial topology and allow it to deploy itself in a process, which is unstable in time, but remains stable—*robust*—at the evolutionary level: we thus obtain the morphology of a process... Biology is thus the preferred field in which to find Thom’s signature of catastrophes, even in experimental curves—which is what J. Viret showed in his experiments, to the joy and surprise of his topologist master!

Finally, the book concludes with historical and biographical anecdotes by **Claude P. Bruter**, one of René Thom’s close travelling companions, whom Thom met very early on, and who was a key figure in the genesis and development of his ideas. Bruter gives us an insider’s view of the famous “Thom seminar” at IHES, in which he was also an early participant. The two scholars forged a friendship based on respect, intellectual exchanges, mutual enrichment and even borrowings. These exchanges made it possible to think as deeply as possible about the decisive notion of “stability”, at the heart of catastrophe theory, but also about an epistemology that strives to understand the dynamic conditions under which discontinuities appear within the stability of entities subject to disturbance...

To sum up, may this collective work bring as much intellectual stimulation to its readers as the authors of this introduction took in organizing this research project. Over these 7 years of work, this has been an incomparable intellectual adventure, which has opened up so many crucial avenues of work, for our sciences today... We now leave it all up to the reader.

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Part I
René Thom Between Philosophy
and Semiotics

Chapter 2

The Form as a Morphology of Process: The Relevance of René Thom for Understanding Individuation



Clément Morier

Thinking about notions such as figure, form, morphology of process, evolving process... leads us to encountering one of the major yet atypical French thinkers of the 20th century, for whom the figure and the form were key words behind any serious explanation concerning the most varied fields of human knowledge. The idea of bringing together science and philosophy—when it comes to examining the explanatory value associated with the handling of certain “archetypical” figures—is one of the singular characteristics of René Thom’s work.¹

However, an *aporia* occurs at once and constantly arises amidst disputes concerning Thom’s discoveries: does not focusing entirely our scientific attention on a singular means of explanation, through forms, lock us up at immediately in the sole framework of *spatiality*? How to give the right importance to genesis and development, whose effects of change seem to require a means of explanation linked more to *temporality*, seen as a metamorphosis, rather than to space? To sum up, is it possible to detect the effects of time through the principles of a form without openly abandoning the stability and solidity which it gives to its object?

Through this *aporia*, we can grasp the striking issues underlying the problem of configuration and the dynamic organisation of the elements contained in an autonomous unity. René Thom’s contribution to these delicate controversies becomes more profound if it enters into discussion with the thought of Gilbert Simondon (1924–1989). This is because he confronted *form* with the terms of its *genesis* and

¹ My warmest thanks and eternal gratitude go to my Mentor Jacques Viret and his memory (1943–2018), for his constant help during my incursion into Thom topology as well as for helping understanding and drawing these figures. *This study is dedicated to him*. It is a reworked and translated version of an earlier work published in *Du mot au concept: Figure*. Grenoble, PUG, 2015. Finally, this text was translated into English by Ian Monk, Member of the Oulipo. Our warmest thanks to him too.

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