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Matter, metaphors, and mechanisms: Rethinking cell theories



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ABSTRACT

This study analyzes the logical structure of classical cell theory (CCT) by pointing out that CCT conceives the properties of organic cellular matter as supervenient to successively emerging states of quasi-crystalline atoms. This concept supports the design of a metaphorical space the intelligible components of which display an explanatory structure in accordance with the contemporary complex-systems approach of mechanisms. These findings support the thesis of an *explanatory turn* within the life-sciences due to a conflict between anti-classificatory (Buffon), analogous (Wolff, Reil, Weber), and causal-mechanical (Kepler) strategies of explanation. The continuous process underlying these diverse discontinuities is taken to be the immanent process of objectifying scientific concepts for the need of explanation. This process repeatedly provides concepts which are identified as nomadic concepts. The meta-analysis of their interactions reveals that concepts of matter are obtained by *idealizations* which entertain one process with three dimensions: *atomization* originating from empirical classificatory regularities (*classification*) and aiming at an explanation of changing phenomena (*dynamization*). These dimensions are successfully incorporated into the explanatory scheme of CCT. The migrations of a second group of nomadic concepts beyond this historical point of transition are made responsible for blurring the explanatory turn.

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1. Introduction

Studies relating to classical cell theory (CCT)¹ diverge considerably within historical, cultural, anthropological, epistemological or philosophical discourses and with respect to the methodological approaches, the intended goals, or the particular aspects selected from CCT. A chronological survey of major contributions to these fields of research may comprise five studies which exemplify this

diversity: three have sought to explain the historical genesis of CCT; one of these has declared the import of concepts, like that of individuality (Canguilhem, 1992),² the other has emphasized preparatory steps taken by preceding investigations (Duchesneau, 1987); the third has embedded CCT in a teleomechanistic research program (Lenoir, 1982).³ Furthermore, the evolutionary state of the adaptation of CCT to the scientific community has been examined (Bechtel, 1984), and, more recently, a group of researchers has focused on the role of the cell as a *nexus* of sciences and technologies (O'Malley & Müller-Wille, 2010).

A decade ago, two studies demonstrated in detail the high degree of complexity of the historical context of CCT (Müller-Strahl, 2004b, 2006b): CCT has been characterized by both a retrospective and an anticipatory *associative power*. Certain facets of CCT can easily be associated with preceding or succeeding theories, others cannot. In order to escape inventive associations, the two studies designed a methodological approach with the aim of raising the

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¹ Terminology: The *Mikroskopische Untersuchungen* (Schwann, 2006 [1839]) will be cited using the abbreviation MU followed by the page number. Properties related to inanimate matter will be identified by the attribute *an-organic*. The scientific community who supported the programmatic contents of CCT will be represented by the collective term *cell theorists*. CCT is not identical with cell theories in general; e.g., in the time before CCT, Meyen had launched a cell theory *sensu stricto* (Müller-Strahl, 2004a); CCT, however, is beyond such theories. Representative cell theorists of relevance for this study are Th. Schwann, H. Lotze and E. Mitscherlich. *Nomadic concepts* are successively introduced by putting a suitable abbreviation in parentheses, e.g., (intusG), or brackets, e.g., [U]. Sometimes, an index clarifies the authorship of the concept. (*Dys-analogies* signifies both analogies and dys-analogies, *c. p.-law* stands for *ceteris-paribus-law*).

² An early account of cell individuality has been presented by Dünge (1899).

³ Cappelletti (1965) had emphasized the teleological aspects of CCT.

internal structure of CCT. The resulting logical framework revealed the links of association to external theories, graduated their influence and excluded others from external association. In general, the internal structure indicates how to organize the environing associative field of theories. Further, a theory, say CCT, is distinguished among a chronological series of specific theories, say other cell theories, if it not only structures the associative field but, above all, *imparts a significant change* to the structures of succeeding theories in comparison to previous ones. Theories with such a twofold power of separation *explain a turn* within the historical development of theories of the corresponding science.

Knowing the internal structure of CCT indicates further viable investigations. For example, the internal structure as such also displays an *internal associative* structure; the associating elements, however, are *principles* which are applied under metaphysical premises to the ordered arrangement of empirical observations in time (Müller-Strahl, 2004b). To dismiss one element of the internal structure will necessarily destroy the integrity of CCT and deprive it of its significance. Among these tightly connected elements, the concept of a *quasi-crystalline substance* is distinguished by its *peculiarity*. This study will demonstrate that the quasi-crystal represents both a *causal* concept with objectifying contents, and a metaphor which grounds the explanatory structure of CCT. The strategy of CCT is conceived as one applying objectifying concepts in order to induce an opaque *metaphorical space* which conceals an intelligible space that can be identified with a mechanistic type of explanation. Thus, the indicated explanatory structure is formally independent of the analogies employed in order to constitute the metaphor. Moreover, these analogies are grafted onto an *objectively* idealized concept of matter. These arguments rebut the traditional interpretation that CCT just employs analogies in order to explain (e.g., Bechtel, 2010) or that its core concept is captured by a theory which attributes functions to parts (most recently, Müller-Wille, 2010).

In consequence, the quasi-crystal turns out to be a pivotal element in two respects: first of all, not only does it design a metaphorical space relevant to guiding future research by appealing to a certain type of mechanistic explanation but, second, it also explains a historical *explanatory turn* with far-reaching consequences. The transition from classification or tentatively causal explanations by making use of analogies or dys-analogies to an era of explanation which sets forth the mechanistic view as the gold standard is marked by the concept of a quasi-crystal. Thus, this concept both represents the *explanans* in the context of a historical explanation demonstrating the *particularity* of CCT, and operates as the atomistic *explanans* of a definite type of explanation representing the *generality* of CCT.

The transition around 1840 can be captured in metaphorical terms as well: Before 1840, the crystal had been the symbol of *causal* physiological research, around 1840 the concept of the quasi-crystal established a metaphorical space which, although short-lived, was decisive for both binding (*συνβαλλεω*) and *uplifting* (*μεταφηρεω*) the concepts of the past to a new era of explanation which superseded the traditional explanatory concepts by offering mechanistic explanations; in this new era, the cell concept turned out to provide a symbol for physiological research (Müller-Strahl, 2006b).⁴ This

⁴ The cell as a *symbol* of physiological research of the 19th century has been introduced in earlier studies (Müller-Strahl, 2006b) and, at the same time, has been shown to imply disconnecting principles. Note that the present study does not examine the *historical* background of the cell concept of CCT (to this special intent, compare, e.g., Teulón, 1986) but rather the *historical* context of its *explanatory* structure which grounds in the concept of the quasi-crystal. Therefore, 'Historical notes' are added once in a while in order to implement the historical material having been selected for this study into the commonly accepted *context of discovery*, not, however, in order to demonstrate historical causation.

study will show that under the influence of the quasi-crystal the *vortex* replaced the function of the former crystal as symbol of organic matter.

The investigations according to these lines of thought set out with Kepler's essay about the *microscopic* morphogenesis of the hexagonal structure of the snow-crystal; this composition is not only an early document of the nomadic partnership between biology and crystallography, but also demonstrates the playful *search* for causal structures underlying (an-)organic formative processes by employing analogies, dys-analogies and mechanisms (Section 2). The major import of Kepler's essay for this study lies in the fact that it contains nearly the complete set of principles which are used much later in CCT to capture the development of the discovered phenomena of cell formation; it lacks, however, both the precise *explanatory structure* of CCT and the ensemble of concepts needed to *objectify* the employed principles. Because of its prematurity the essay was ignored in the major lines of development of empirical crystallography. However, it reentered the discourse of cell theorists two and a half centuries later.

Another neglected point of reference in this discourse has been Weber's comparison of crystals and organisms (Section 3). This highly developed paradigm of the traditional way of analogical thinking is a representative collection of classical physiological problems relating to the organization of matter in the course of *macroscopic* morphogenesis. More specifically, it ties together diverse nomadic concepts vagabonding between crystallography and the life-sciences. Weber's struggle for objectification will be shown to be insufficient in a supra-individual sense. In order to elaborate on the reasons of this failure, the objectifying principles of analogies are examined separately (Section 4). Kepler, Buffon, Wolff, Reil and Weber are the protagonists of this survey. The strategy of analogous explanation will be analyzed according to its *form*, *sense* and *tendency*, and the concept of a *dys-analogy* will be introduced which, basically, is a counterfactual analogy. These steps prepare the analysis of the structure of CCT and the rearrangement of concepts in a transitory phase of physiological research around 1840 (Section 5). The concept of a metaphorical space is introduced which, in the case of CCT, is extended by means of the concept of a quasi-crystal. Having specified this concept, the problem shows up to capture the common points and differences between earlier explanatory strategies and that of CCT. The (dis-)continuities of this transition will be analyzed by means of a first type of nomadic concepts (Section 6).

Furthermore, the intelligible explanatory structure of CCT will be shown to be in close accordance with concepts of mechanisms discussed at present in the philosophy of science (Section 7); the rationale of this section receives support from a recent publication (Müller-Strahl, 2012).⁵ The contrast between explanatory concepts of preceding theories and those of CCT, and the harmony between CCT and contemporary theories will reveal the *explanatory turn*. The metaphorical component of CCT was short-lived—its explanatory one was advanced more or less immediately to promote a successful research program. This novel step of CCT, however, did not have immediate repercussions in all branches of physiological research. In order to understand the phenomenon of blurring the transition to a new explanatory concept, a second type of border-crossing nomadicity will be examined by employing the conceptual tools provided by CCT (Section 8).

To summarize, the discontinuity with respect to explanation around 1840 will be perceived as an event emerging from the confrontation of disparate explanatory strategies which reveal to

⁵ A concise introduction to Lotze's philosophy has been presented recently by Beiser (2013).

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