

An Interdisciplinary Approach to Morphogenesis

Chenling Xu Antelope¹, Lars Hubatsch², Juste Raimbault^{3,4,*}, and Jesus Mario Serna⁵

¹University of California, Berkeley, US

²The Francis Crick Institute, London, UK

³UMR CNRS 8504 Géographie-cités, Paris, France

⁴UMR-T 9403 IFSTTAR LVMT, Champs-sur-Marne, France

⁵Université Paris VII, Paris, France

*juste.raimbault@polytechnique.edu

ABSTRACT

The notion of morphogenesis seems to play an important role in the study of a broad range of complex systems. If the concept was introduced in embryology to design growth of organisms, it was rapidly used in various fields, e.g. urbanism, geomorphology and even psychology. However, the use of the concept seems generally fuzzy and to have a field-specific definition for each use. We propose in this paper an epistemological study, starting with a broad interdisciplinary review and extracting essential notions linked to morphogenesis across fields. It allows to build a consistent general meta-framework for morphogenesis. Further work may include concrete application of the framework on particular cases to operate interdisciplinary transfers of concepts, and quantitative text analysis to strengthen qualitative results.

Keywords : Complex Systems, Morphogenesis, Applied Epistemology, Interdisciplinarity

Introduction

During every historical period, people use the main technological advance as a metaphor to explain other phenomena in nature. First, nature was mechanical, then electrical, and now computational. Here, we suggest that taking an alternative metaphor might allow us to better study some properties of a system, and study how the concept of morphogenesis that originated in the study of developmental biology, can be used across systems. Morphogenesis is a very powerful metaphor that is distinct from the previous three that have been very popular in history. Unlike the mechanical, electrical or computational explanations of nature, morphogenesis is not a human designed process. Morphogenesis emphasizes the role of change and growth, rather than a static state. "... natural history deals with ephemeral and accidental, not eternal nor universal things ..." ¹ The goal of this paper is to study three questions:

1. How is morphogenesis defined in different fields?
2. Are there fields that use approaches and concepts that embody the notion of morphogenesis but do not use the word?
3. Can approaches to study morphogenesis be applied across different fields?

A similar effort is described in ², but it consists more of a collection of viewpoints from subjects that can be related to morphogenesis rather than an epistemological reconstruction of the notion as we propose to do. Furthermore, examples are far from exhausted and our review is thus complementary.

The rest of this paper is organized as follows : we provide first a compartmentalized review of the notion of morphogenesis across various fields, ranging from biology to social sciences, psychology and territorial sciences. A synthesis is then made and a framework as general as possible proposed. We finally discuss further developments and potential application of this epistemological analysis.

¹Thompson, D. W. On growth and form. (1942).

²Bourgine, P. & Lesne, A. Morphogenesis: origins of patterns and shapes (Springer Science & Business Media, 2010).