Homology & Archetype, Analogy & Prototype, Hypothesis & Truth as Sources of Knowledge

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A *Structural archetype* is defined in this article as follows, see also Owen (1866, p.146):
(H1) A *Schematic plan*, or a topological map characterizing the structure of a complex system or organism by its layout of organization from constituent parts, or by its pattern of construction from basic components. (H2) Moreover, two distinct organs or organism described by the same or similar structural archetypes are said to be *homologous*. (H3) For example, the following forelimbs of distinct (Mammalia) animals share homologous skeleton structures, although having different functions: Bats' wings, for flying; Whales' flippers, for swimming; Moles' arms, for digging; Human arms, for object manipulation. (H4) Furthermore, in the context of modern theories of biological evolution, homology may be a useful tool for investigating and tracing distinct paths of phylogenetic development diverging from a common ancestor, as it is the case in the last example.

A *Functional prototype* is defined in this article as follows, see also Owen (1854, p.263):
(A1) A *Humanly invented machine*, or a *Proof-of-concept model*, or a *Proof-of-principle device* demonstrating the key functional aspects of a system, that provides an analogy explaining how something else, be it a natural organism or a constructed artifact, actually works or can possibly work in order to achieve its purpose. (A2) Moreover, two distinct organs or organism explained by the same or similar functional prototypes are said to be *analogous*. (A3) For example, humans (Chordata) and octopi (Mollusca) have organs designated by the same name, eyes, for they are used for a similar purpose, namely, vision. The key functional aspects of all these organs can be explained by analogy to a photographic camera, its lenses and focus mechanisms. (A4) Furthermore, in the context of modern theories of biological evolution, analogy may be a useful tool for investigating convergent paths of phylogenetic development, as it is the case in the last example.

Richard Owen (1804-1892) developed the concepts of homology and analogy and used them in his studies of comparative anatomy of animals. After Charles Darwin and Alfred Russel Wallace published their versions of the theory of biological evolution, in 1859, homology and analogy became important tools for tracing divergence and convergence relations in phylogenetic evolution. Karl von Frisch and Konrad Zacharias Lorenz shared a Nobel prize (1973) for their discoveries concerning the organization and elicitation of individual and social behavioral patterns. In their work, homology and analogy are fundamental tools of investigation, see Lorenz (1935, 1974, 1978) and Frisch (1954, 1974). Nevertheless, in spite of (or because of) the ever expanding use of these conceptual tools, their use has been plagued by pernicious and persistent logical and statistical fallacies.

According to Boyden (1943): *Owen distinguished two chief kinds of resemblance in corresponding organs or parts of the bodies of different animals: (1) essential* structural agreements *relating particularly to relative position and connections; (2)* similarities in the function *or use to the organism. These are really different qualities and they have* no necessary dependency *upon each other.*

In spite of Boyden's clear warnings, logical fallacies are often engendered by introducing spurious logical dependencies between the concepts of homology, analogy, divergent evolution from a

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common ancestor, and convergent evolution to a common objective, see Hall (1994). For example: (F1) Although homology is often used to test for common ancestry, some authors include common ancestry in the definition of homology, a classical fallacy engendered by inverting an implication; or (F2) Although, in some situations, homology and analogy offer valid alternative or complementary explanations for issues of interest, some authors define homology and analogy as mutually exclusive, a classical fallacy engendered by having the full relational possibilities contemplated by an hexagon of oppositions reduced to a square, see Stern et al. (2018, 2024, 2025) for related comments.

Furthermore, homology refers to similarities in structure often described by discrete coincidences between interconnection diagrams, as in example H3, while, in contrast, analogy refers to similarities in function often described by continuous mathematical models, as in example A3. This situation leads to statistical fallacies that are even more prevalent than their logical counterparts, for example: (F3) Some authors use discrete statistical models, that are appropriate to test homology, in contexts where analogy could best be tested using continuous statistical models, see Haldane (1954) and Stern et al. (2014, 2017, 2020, 2025). The study of the aforementioned logical and statistical fallacies and appropriate ways and methods to correct them is the main goal of this article.

Finally, this article extends the discussion of aforementioned topics to the field of Ethology, by investigating how homology and analogy may be used to characterize the (phylogenetically) *inherited symbolic* (i.e. analogical) (communication structured as a) *language* of the honeybees.

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