
ANTIDOTE TO AN ILLUSION

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In a volume dedicated to Goethe's contribution to the biological sciences, published on the 150th anniversary of his death, T. Lenoir wrote:

In the decade marking the centenary of Darwin's death as well as the 150th anniversary of Goethe's death, it is tempting to treat the work of Goethe and his cohorts as the rudimentary beginnings of a scientific discipline which would acquire its firm foundations some sixty years later in the work of Darwin... But such an ecumenical gesture would fail to appreciate the true significance of the movement initiated by Goethe, Treviranus and others. For the science of life they set out to found is not the one extolled in textbooks today. In truth, the works of Goethe and Darwin present us with two radically different conceptions of biological science, both capable in their own right of organizing the phenomena of life and serving as a basis for progressive empirical research (Lenoir 1987, p. 17).

The field of morphology originated from Goethe's conception of nature, where the term, coined by him, referred to the study of the internal laws guiding the formation of body plans and organ forms. As stressed by Lenoir (1987), the search for these "laws of form" turned out to be a questionable enterprise in Darwin's view, where living matter, deprived of a "inner formative force" or *Bildungstrieb*, had to be shaped externally, as functional adaptations to environmental demands—the presumed creative force. Taking into account that this view has dominated the biological sciences for a century and a half, it might be thought that the present framework was established after a period of time in which alternative theories were refuted and finally laid to rest. However, a retrospective view to the issue reveals a different picture (Linde-Medina 2010).

On the one hand, by switching from an internal to an external organizing agency, the Darwinian view treated the problem of form generation, which occupied a central role in biology at its birth, as a "black-box." According to the theory of natural selection, the knowledge of the mechanisms underlying morphogenesis and pattern formation at early stages of development are irrelevant for understanding biological form, insofar as the production of new morphological variants is undirected, continuous

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and gradual. This requirement is necessary for the mechanism of natural selection to be capable of *shaping* biological structures over the course of evolution (Gould 2002).

On the other hand, the emergence during the twentieth century of the new physics of soft, chemically and mechanically excitable media, which include living matter, has finally allowed the scientific formulation of the internal organizing principles of biological form, as was anticipated by Goethe and other advocates of the “internalist” tradition (Newman and Linde-Medina 2013). Anyhow, if living matter possesses an inherent capability to acquire form by itself as a consequence of its intrinsic material properties, the physico-chemical processes underling morphogenesis and pattern formation of the early embryo—and not a subsequent sorting mechanism like natural selection—would be the *causative factor* of the resulting morphological outcomes, the latter principally playing a stabilizing role (Newman and Linde-Medina 2013). Thus, the division presented by Lenoir (1987) is not merely of philosophical or historical interest: the two opposing conceptions of nature exemplified by Goethe and Darwin are, in fact, as alive today as they were 150 years ago. However, the “internalist” tradition has been marginalized to such an extent that Darwinism is wrongly regarded as the only materialistic approach for the study of organismal form.

It has been argued that these two views could be complementary as long as Darwinian explanations were confined to small, quantitative morphological changes of existing structures which would be *originated* not by a gradual evolutionary reshaping, but suddenly, by small alterations in the underlying morphogenetic mechanisms, which means that they would represent potential morphological outcomes of the developmental systems (Müller and Newman 2005). In the conventional evolutionary view, however, it is assumed that micro and macro-evolutionary changes are not qualitative different phenomena; both would be the result of a continuous and gradual reshaping by natural selection, and larger morphological changes would be the consequence of that mechanism being operative over larger time spans. We have argued that this mode of evolution contains an implicit notion of development, which is only applicable in some cases (Linde-Medina and Newman 2013). Even so, in a true Procrustean style, the Darwinian framework continues to be applied even when it means to leave fundamental aspect of embryogenesis aside, as in the case of the bird beak (reviewed in Linde-Medina and Newman 2013).

Regarding the forum question: ¿How does your professional practice create social value, i.e., how it participates in the development of society?

In a review of Darwinism dated from 1908, Kellogg wrote:

The fair truth is that Darwinian selection theories, considered with regard to their claimed capacity to be an independently sufficient mechanical explanation of descent, stand to-day seriously discredited in the biological world. On the other hand, it is also fairly tru[e] to say that no replacing hypothesis or theory of species-forming has been offered by the opponents of selection which has met with any general or even considerable acceptance by naturalists... we are immensely unsettled (p. 5).

By the 1940s, the emergent Modern Synthesis had in fact suppressed dissenting views, establishing the hegemony of Darwinism in considering the study of organic form. It is well-known that this "consensus" was reached by excluding the participation of leading embryologists of that period (Hamburger 1980). It seems this was not a casualty. As pointed out by Hamburger (1980), it is not clear if embryologists did not participate by opposition or indifference to the Modern Synthesis, yet an idea united them: "They were all evolutionists and they all conceded the effectiveness of natural selection, at least to some extent. But many had misgivings about a key dogma of the Modern Synthesis; namely, the claim that natural selection is the sole explanation of all adaptations (p. 98)."

The omission of development from the evolutionary explanatory picture is based on the idea that form is *encoded* in genes, i.e., the metaphor of a genetic program for development. Under this assumption, development is logically excluded from the study of evolution not because it is denied that complex physico-chemical processes take place each generation from the zygote to the newborn, but because these developmental processes are considered only as the proximate cause for the generation of the organism, i.e., they have no role in *predicting* the resulting form, which would be ultimately due to a genetic program built up by continuous episodes of natural selection for marginal adaptation.

Nowadays the conventional view is so deeply ingrained that its foundations are taken for granted. It occurs despite the fact that the conception of living matter underlying the logical structure of Darwinism has proved untenable in the light of advances in developmental genetics and physics of soft, excitable media (Newman and Linde-Medina 2013). In the present state of affairs, we are faced with a choice: we could ignore these new findings and continue to reside in the echo chamber of an obsolete theory; alternatively, we might prefer to resist the intellectual lethargy instilled by the Modern Synthesis and work toward a better science of form. Society never benefits from misapprehending reality. I hope my scientific practice can, in some way, further the efforts of those who choose the second option.

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