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Making the case for orthogenesis: The popularization of definitely directed evolution (1890–1926)

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ABSTRACT

Throughout the history of evolutionary theory a number of scientists have argued that evolution proceeds along a limited number of definite trajectories, a concept and group of theories known as "orthogenesis". Beginning in the 1880s, influential evolutionists including Theodor Eimer, Edward Drinker Cope, and Leo Berg argued that a fully causal explanation of evolution must take into account the origin and nature of variation, an idea that implied orthogenesis in their views. This paper argues that these orthogenesis developed theories that were more than highly technical and theoretically dubious hypotheses accessible only to elite specialists, as certain histories of these ideas might suggest. Some orthogenesists made their case to a non-specialist audience to gain support for their ideas in the face of widespread controversy over evolutionary theory. Through a case study analysis of three major books by Eimer, Cope, and Berg, this paper contends that they sought to re-orient the central tenets of the science of evolution to include the causal impact of variation on evolutionary outcomes. These orthogenesists developed novel and synthetic evolutionary theories in a publishing platform suited for non-specialist audiences in an effort to impact the debates over evolutionary causation prevalent in the late-19th and early 20th centuries.

1. Introduction and context

The relationship between science and the public has changed dramatically throughout the past few centuries (Bensaude-Vincent, 2001). The complex relationship between the nature of science and science popularization often requires investigators to focus on a narrow set of scientific theories, practices, or negotiations within a limited timeframe or set of related ideas. The goal of this special section of papers is to explore the dynamic relationship between evolutionary theory, popularization of evolution, and changes internal to the study of evolution (see: Smocovitis, Shapiro, Perez, Sepkowski, this issue). To investigate this relationship fully, we must understand how these factors changed over time, drawing conclusions after scrutinizing particular cases closely. This paper contributes to ongoing discussion of science popularization by probing the motivations and approaches for making the seemingly obscure evolutionary theory of orthogenesis (evolution in definite directions due to limitations on variation) more widely known outside a specialist audience between 1880 and 1930.

The years between 1880 and 1930 were a fascinating and complex period for evolutionary theorizing (Bowler, 1983), yet the involvement and impact of non-specialists in these debates remains under-explored. This was an era of rapid changes in how scientists understood the processes of heredity, development, and evolution. Biologists theorized and intensely debated the mechanisms, phenomena, and outcomes that 'mattered' for a comprehensive explanation of evolution (e.g. Delage & Goldsmith, 1913; Dennert, 1905; Kellogg, 1907). Changes in theories of development had significant implications for theories of heredity and evolution. Reciprocally, changes in theories of heredity held large implications for evolution and development. These ideas were in flux and deeply interconnected. Concerning evolution, these changes in related theories had large implications for what Steven Jay Gould has characterized as the "agency, efficacy, and scope" of a particular evolutionary mechanism (2002): agency is the unit on which

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the mechanism acts; efficacy is the power of the mechanism to operate in nature; and scope is the extent to which that mechanism can explain the diversity and history of life on earth. In the decades surrounding 1900, evolutionists debated and negotiated the explanatory power and evidential basis of various theories of evolution.[1]

Focusing closely on how orthogenesists communicated their ideas to non-specialist audiences between 1880 and 1930 shows one perspective of the complex relationship between evolutionary theory and public, non-specialist audiences. Emphasizing orthogenesis contributes to ongoing discussions in the history of evolutionary theory and science popularization (e.g. Lightman, 2007, 2010). This paper analyzes the major books of three prominent and well-respected evolutionists. The Swiss-German zoologist Theodor Eimer wrote *Organic Evolution* in 1888 (English trans., 1890) in response to the hereditary and evolutionary work of his teacher August Weismann. Building on a lifetime of writing about evolutionary theory and patterns of evolution, the popular American paleontologist Edward Drinker Cope wrote *Primary Factors of Organic Evolution* (1896) as a synthetic treatise incorporating his findings from years, and many dollars, spent hunting for new fossil vertebrates. The Soviet biogeographer and taxonomist Leo Berg produced his treatise on definitely directed evolution titled *Nomogenesis: or Evolution According to Law* in 1922 (English trans., 1926). These three books, written by these three theorists, provide excellent case studies of the motivation and approaches used by orthogenesists make their case to a non-specialist audience.

The role of orthogenesis in the history of evolutionary theory is somewhat unclear. This is in part a consequence of the mischaracterization of theories of orthogenesis by advocates of neo-Darwinism. For example, noted evolutionist Ernst Mayr wrote that "until natural selection was fully understood, many evolutionists, from Lamarck to H.F. Osborn to Teilhard de Chardin, postulated the existence of a non-physical (perhaps even non-material) force which drove the living world upward towards ever-greater perfection (orthogenesis)" (Mayr, 1982). While aspects of this quotation represent small portions of individual theories, many proponents of orthogenesis were, on the whole, materialists and mechanists rather than cosmic teleologists or vitalists advocating non-physicalist forces. Another opponent of orthogenesis, albeit more sympathetic than Mayr, Julian Huxley used "the eclipse of Darwinism" metaphor to characterize these theories in this period. The historian Peter Bowler adopted this metaphor (Bowler, 1983; Huxley, 1942) that presumes Darwinism's triumphant return and the inevitable failure of alternatives like orthogenesis (Largent, 2009). Beyond mischaracterizations and problematic metaphors of orthogenesis, other histories present the theory as highly technical and theoretically complex (Levit & Olsson, 2006). Indeed, scanning the literature of orthogenesis we find many foreign concepts and complex Greek-based words that seem to support this notion: bathmysm, physiogenesis, kinetogenesis, aristogenesis, genepistasis, halmatogenesis, and kyesamechania. In this period of evolutionary theory it was common to postulate laws of development and evolution, a theoretical construct used to characterize phenomena operating under constraints or in regular patterns. These terms and law-based thinking strike the twenty-first century reader as a bizarre and problematic, potentially indicative of highly specialized and dubious theorizing. But these traditional descriptions of orthogenesis are not entirely correct.

There was more going on among the proponents of orthogenesis than jargonizing and dunder-headed theorizing only accessible to the scientific elite. Focusing on three major books by Eimer, Cope, and Berg this essay shows that these authors intended their books to be read by a wide, non-specialist audience. They each structured their books such that their theories answered general questions in evolution: Eimer argued that orthogenesis provides the best explanation of evolutionary novelty; Cope maintained that his theory of orthogenetic evolution could account for the full evolutionary history of the fantastic new fossils dug out of the Western territories in the United States in the late 1800s; and Berg promoted an account of evolution as a highly structured and non-random process.

The second argument in this paper posits that orthogenesists went beyond crafting their books for a non-specialist audience; they developed novel and synthetic theories that placed the origin and nature of variation as a central and indispensable causal component of any comprehensive explanation of evolutionary causation. Eimer, Cope, and Berg all contended that a theory of evolution that excluded the impact of new variation on evolutionary trajectories was incomplete. The brief analysis conducted in the second half of this paper shows that the central motivations for writing their books was to re-orient the basic factors on which evolutionary theory was grounded to focus on the role of variation.

These two theses, that orthogenesis was not only for specialists and that it focused on the causal role of variation in evolution, provides new perspectives on what orthogenesists were doing and how they did it. Within the context of science popularization, the theories in these non-specialist books were significant pieces of new theory; this was not simply a case of scientists translating pure science into language comprehensible to lay-audiences. As such, this paper shows how orthogenesists were a part of a different approach to science popularization. Because they sought to popularize an alternative to the prevailing theory of neo-Darwinism,[2] they endeavoured to influence the core tenets of evolutionary thinking in a period of intense theoretical upheaval. This approach shows that the boundaries between elite specialists and amateurs as implied by traditional models of science popularization-as-translation does not apply in this case.

2. Making the case for orthogenesis

The decades between 1880 and 1930 pose a challenge to historians of evolutionary theory in part because there was no clear hegemony over the most significant mechanism of evolutionary causation. One consequence of this turmoil is that the reasons why scientists would endeavor to make their work appealing to non-specialist audiences are not immediately clear. Nevertheless, the debates over the mechanism of evolution saw specialists making their work accessible to wide, non-specialist audiences to gain support for their theory. Evolution was a theory of general interest in this time period, and investigators from across various academic disciplines were interested in the outcomes of the debates over evolutionary causation. Focusing on evolution generally, and orthogenesis specifically, shows that these theories had not become so specialized that the central ideas were inaccessible to non-specialists. This first section emphasizes how major proponents of orthogenesis presented their ideas for a non-specialist audience.

[1] There were numerous different theories of evolution under consideration at this time, including: neo-Darwinism, saltationism, orthogenesis, neo-Lamarckism, orthoselection, etc.

[2] For the purposes of this paper the term "neo-Darwinism" is used consistently with how it was employed in the early 1890s. The term denoted the views of individuals like Weismann, who considered natural selection to be capable of fully accounting for evolutionary change (Bailey, 1894). Eimer's translator, Joseph T. Cunningham used this term consistently in *Organic Evolution* in reference to Weismann's evolutionary theory based on germ-plasm heredity (Eimer, 1890).