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Évolution

Quelques apports à la théorie de l'Évolution, de la « Synthèse orthodoxe » à la « Super synthèse évo-dévo » 1970–2009 : un point de vue

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Résumé

La « synthèse moderne » de la biologie évolutionniste a structuré et revitalisé la théorie de l'évolution à partir des années 1930 et 1940. Elle mettait en avant la puissance explicative de la sélection naturelle et des changements graduels pour rendre compte des processus qui gouvernent aussi bien le devenir des populations naturelles aujourd'hui que le vaste déroulement historique de la vie dans son ensemble. Au cours des 40 dernières années, la synthèse a été contestée sur des fronts variés, allant de la paléontologie à la biologie du développement, en passant par la systématique, la biogéographie et la biologie moléculaire. En conséquence, beaucoup de ses propositions centrales en ont été changées ou modulées, mais aussi étendues et amplifiées. Dans quelle mesure la « Super synthèse » actuelle restera opérationnelle dépendra de sa capacité à tester ses propositions centrales et l'efficacité de ses mécanismes principaux par les données émanant des nouveaux champs de recherche. ***Pour citer cet article : A. de Ricqlès, K. Padian, C. R. Palevol 8 (2009).***

Abstract

Some contributions to evolutionary theory, from the "orthodox" Synthesis to the "Evo-devo Super synthesis" 1970–2009: A point of view. The "Modern Synthesis" of evolutionary biology coalesced and revitalized evolutionary theory beginning in the 1930s. It stressed the explanatory power of natural selection and gradual change to account for the processes that govern natural populations today, as well as patterns in the history of life. In the past 40 years, the synthesis has been challenged on various fronts ranging from paleontology to developmental biology, systematics, biogeography, and molecular and developmental biology. Several of its central propositions have been modified and expanded as a result. How well the synthesis continues to be effective will depend on its continued ability to test its central propositions and the efficacy of its central mechanisms, particularly on the basis of new evidence from emerging fields of study. ***To cite this article: A. de Ricqlès, K. Padian, C. R. Palevol 8 (2009).***

Mots clés : Évolution ; Darwin ; Histoire de la biologie ; « Synthèse moderne » ; Biologie du développement évolutionniste

Keywords: Evolution; Darwin; History of biology; "Modern Synthesis"; Evolutionary developmental biology

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A study of the effects of genes during development is as essential for an understanding of evolution as are the study of mutation and that of selection. J. Huxley 1942, quoted by S.B. Carroll 2008.

« *Une étude des effets des gènes au cours du développement est aussi essentielle à la compréhension de l'évolution, que le sont l'étude de mutations et celle de la sélection* ».

We need an expanded version of Darwinian theory to explain how natural selection operates, not only on organisms but on a hierarchy of units under selection – genes, organisms, local populations and species. S.J. Gould in R.T. Bakker 1985.

« *Nous avons besoin d'une version élargie de la théorie de Darwin pour expliquer comment opère la sélection naturelle, non seulement sur les organismes, mais aussi sur une hiérarchie d'unités soumises à la sélection – gènes, organismes, populations locales et espèces* ».

Abridged English version

Introduction

The spread of Charles Darwin's ideas [17], both during his lifetime and since, in a variety of domains including anthropology, economics, politics, and philosophy, has fostered a variety of interpretations of his thought, many of which are debatable or contradictory, and actually represent a betrayal of his ideas. In this essay, we treat mostly the evolution of evolutionary theory since the 1970s, when the Modern Synthesis was challenged by new developments in various fields.

In his last great work, Stephen Jay Gould [50] set out three distinct possibilities for the future of evolutionary theory: (1) accept that the synthetic theory had failed in its fundamental propositions and either reconfigure it drastically or abandon it; (2) account for and incorporate new evidence that will lead to a reconstruction and expansion of the theory, without destroying its fundamental tenets; or (3) conclude that new discoveries, whatever their scope, do not require any substantial revision of the theory [89].

New discoveries and views of the past 40 years have come from all levels of integration of the biological sciences, as well as the earth sciences. The integration of molecular information (genomics, developmental genetics) has brought new understanding of evolutionary processes, while systematics and plate tectonics, for example, have broadened our understanding of the dynamics that contribute to large-scale evolutionary patterns. Our current understanding of evolutionary patterns and processes relies as much on fine-scale molecular aspects as on highly integrative ones. However, we will concentrate on the "macroworld" of organismal biology, including systematics and paleontology.

The evolution of the Synthesis: challenges and expansions

By the 1970s, the "orthodox" synthesis [46,47,102] had gained acceptance of the great majority of biologists and paleontologists. It showed a remarkable ability to incorporate new discoveries from a variety of fields [80,115]. However, a certain discontent was rooted in deep challenges from several quarters, whether sociological, epistemological, or scientific. A growing dialectic between evolutionary patterns and processes [71,85] had been neglected by the orthodox synthesis.

Origin and evolutionary value of adaptations

In classic synthetic theory, evolutionary transformation is adaptive and occurs slowly and gradually, cumulatively, by the addition of small modifications under the control of natural selection. But, if the phenotypic changes produced by mutations are so tiny, how can they initiate the adaptive modification of the organism so that it becomes the "target" of a selection that specifically favors their persistence? Recent advances in ecophysiology and genetics consider that heritable adaptive changes are initially physiological, ecological, and behavioral, and that morphological modifications are coalesced only later in the process. So the real "targets" of natural selection could initially be non morphological.

The problem of gradualism

Since Darwin, it has been customary to consider that all evolutionary change is slow, gradual, and cumulative. This point of view was strongly reinforced by mathematical models of population genetics, and it completely suffused the reading that the paleontologists of the Modern Synthesis, under the influence of Simpson [106], made of the succession of fossils in the stratigraphic column. But gradualism was jeopardized by a theoretical difficulty of scale: namely, repeated changes in the same direction comprised a pattern of orthoselection [106]. Such difficulties were doubtless why some noted biologists of the 20th century were ambivalent about the synthetic theory or even rejected it.