DEVELOPMENTAL GENETICS AND EVOLUTION

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The conceptual realm of Biology deals with interactions and transformations of forms, be they molecules, cells, organisms or societies. In fact, the terms transformation, evolution and development have been used interchangeably throughout the history of Biology. Now the conceptual contents of development (ontogeny) and evolution (phylogeny) correspond to two distinct disciplines. Since the beginning of this century their goals, concepts and methods have been mutually irreducible, this despite the early awareness that a causal explanation of evolution required the understanding of development, because somehow the forms of the ancestors were recapitulated in the development of the derived organisms. I will try to show here how molecular genetic analysis is connecting and merging both disciplines into a common conceptual realm.

The young discipline of genetics provided the conceptual foundations for a new paradigm of evolution as manifested in the "New Synthesis" in the 30's. Mutational polymorphism constituted the bases for selection of new, adaptive, allelic combinations. Artificial selection for desired traits could readily pool a large variety of favourable allelic combinations, albeit of rather unspecific nature. The genome was then conceived as a plastic device for opportunistic arrangement of adapting alleles. When these alleles (for secondary metabolism enzymes) could be monitored in electrophoretic gels, geographic clines of frequencies were detected. By extrapolation evolution became a matter of external changes, adapting allelic polymorphisms and time: a long contingent process, a sequence of historically unfathomable events.

Developmental genetics in the 70's starts moving from describing phenotypes of mutant enzymes to dealing with systemic (homeotic) mutations and embryonic lethals. Both were autonomously affecting specific cell behaviour and differentiation. When developmental genetics analysed the molecular nature of the corresponding wildtype genes and compared them in very distant organisms a new vision of evolution emerged. These were specific genes which direct specific developmental processes by regulating the expression of other genes. More importantly, these genes were conserved in evolution. Molecular genetics later extended this finding to multitudes of genes and their functional groups (syntagmata). These teams of conserved genes are called upon to work, by transcriptional or posttranscriptional gene regulation, to carry out specific developmental operations. Morphogenesis could then become reducible to genetic operations. Thus, development became a matter of combinations of conserved syntagmata operating in cells of different lineages, and evolution a matter of changing these combinations in phylogenetic lineages. The source of genetic variation appears to be based on a high DNA turnover allowing for changes in the organisation of regulatory regions of genes.

Our current challenge is to understand how minimally complex genomes produced such diverse morphologies during the short period of 20-50 My. of the Cambrian explosion. The rest of evolution seems a mere increase in decoration by comparison. This challenge extends to explaining how natural selection filtered mutational propositions in regulatory regions and fixed them in phylogenetic lineages.