2 Overview

Today I'll give a brief overview of evolutionary developmental biology.

2.1 A New Spin on Old Ideas

Evo-devo is the modern incarnation of earlier research interests. For example:

- Karl Ernst von Baer (1828) formulated a series of generalizations ("laws") about embryonic development[2,3]. They can be paraphrased in two major points as follows. First, early embryonic stages of related organisms are identical; distinguishing features are added later. Second, young embryos are undifferentiated general forms, not adult ancestors.
- Charles Darwin wrote extensively on problems of evolutionary developmental biology in chapters V ("Laws of Variation") and XIII ("Mutual Affinities of Organic Beings: Morphology: Embryology: Rudimentary Organs") of the 1st edition of "The Origin"[4] . For example, he recast von Baer's laws in evolutionary terms.
- Ernst Haeckel, an early disciple of Darwin, attempted to synthesize evolution and development. He formulated the "Biogenetic Law" that ontogeny recapitulates phylogeny[2,5]. "Recapitulationism" became very influential in biology, and remained so well into the 20th century, but has since been discredited.

2.2 A Powerful Analogy

Parallels between evolution and development have often been noted perhaps because they are both the outcome of branching processes. Indeed, in the 19th century the word "development" was used to describe what we now call "evolution"). Just as extant species have arisen from the division of ancestral species, so the cells extant in an adult animal have arisen from the division of ancestral cells earlier in development. Under this analogy, the cell lineage would correspond to a phylogeny, a cell to a species, a cell fate to a character state, and cell division to speciation. However, analogies can be misleading: analogy does not necessarily imply a similar mechanism, Haeckel notwithstanding.

2.3 The Missing Link

The Modern Synthesis of evolution and genetics that developed during 1930s and 1940s notoriously lacked a "theory of development": natural selection "sees" phenotypes, and phenotypes

somehow develop through an interaction between genes and the environment. But how exactly? And how do these developmental mechanisms evolve? And do the mechanisms themselves affect the course of evolution? Several researchers (e.g. Conrad H. Waddington, Richard Goldschmidt, Ivan Ivanovich Schmalhausen) worked on such questions, but their efforts were largely independent and disconnected[6]. The resurgence of interest in Evo-Devo had to wait for the advent of molecular developmental biology[7].

2.4 The Two Cultures

Evolutionary developmental biology results from the convergence of two fields: developmental biology (DB) and evolutionary biology (EB). However, these disciplines have quite different scientific traditions[3]. For example:

- When trying to explain a given structure, function or behavior, DB concentrates on proximate causality (e.g. gene action, cell-cell interactions), while EB concentrates on ultimate causality (e.g. natural selection).
- EB is particularly interested in phenotypic variability as the raw material for natural selection, while DB tends to ignore variability, and concentrate on robust, orderly aspects of development.

2.5 The "Postmodern" Synthesis

The aim of Evo-Devo is to study:

- how developmental mechanisms are shaped during evolution
- how developmental processes influence evolution

This new synthesis draws from, among others, the following fields: cell, developmental and evolutionary biology; comparative embryology and morphology; molecular, population and quantitative genetics; genomics; life-history evolution; experimental evolution; paleontology; theoretical and computational biology; phylogenetics; ecology. (Déjà vu, anyone?)

2.6 Next Lecture

Next week we shall *really* begin our exploration of Evo-Devo. The first stop will be the concept of canalization introduced by C. H. Waddington. The required papers are one of Waddington's classics[8] and a modern spin-off[9].

2.7 Literature Cited

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