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PII: S0044-5231(15)00041-8
DOI: http://dx.doi.org/doi:10.1016/j.jcz.2015.04.006
Reference: JCZ 25335

To appear in:

Received date: 30-1-2015
Revised date: 27-4-2015
Accepted date: 27-4-2015

Please cite this article as: Wagner, Günter P., Evolutionary Innovations and Novelties: Let's get down to business!.Zoologischer Anzeiger - A Journal of Comparative Zoology http://dx.doi.org/10.1016/j.jcz.2015.04.006

Evolutionary Innovations and Novelties: Let's get down to business!

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Abstract

One of the important unanswered questions in evolutionary biology is how evolutionary innovations originate. Recent advances in evolutionary developmental biology and genomics have put the developmental, mechanistic aspects of evolutionary change into the hands of evolutionary biologists and we now have the means to acquire an experimentally grounded understanding of this important phenomenon. In addition to the technical advances the field requires clarity about the research agenda: what is it that we need to know in order to understand evolutionary novelties and innovations. One critical insight is that the vernacular notion of "innovation" covers at least three distinct phenomena: the evolution of a novel functional capacity, the origin of a novel body part (type I novelty), and the radical transformation of a pre-existing body part (type II novelty). Here I argue that these three phenomena are the result of different kinds of biological processes and thus require different research approaches to be addressed. For the origin of novel body parts a research agenda is outlined based on the hypothesis that body part identity is constituted by the activity of a core gene regulatory network that mediates between positional information signals and so-called realizer genes. Under this perspective the origin of a novel body part or cell type is identical with the origin of a novel core gene regulatory network that endows the novel body part with developmental and variational individuality. Technical approaches to investigate the origin of novel core regulatory networks are briefly discussed.