Onward and Outward

Author: Beardsley, Timothy M.

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Editorial Correspondence: 1444 I Street, NW, Suite 200, Washington, DC 20005; telephone: 202-628-1500; fax: 202-628-1509; e-mail: bioscience@aibs.org. Instructions for preparing a manuscript for *BioScience* can be found at *www.aibs.org/bioscience/resources/Info_for_contribs.pdf.*

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Organisms from Molecules to the Environment

American Institute of Biological Sciences

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The philosophical tension between researchers who pursue explanations of complex phenomena in terms of small-scale, even molecular, events and those who stress the importance of large-scale context and contingency has been characteristic of biological and philosophical debate for decades. The academics building their careers on explaining and commenting on the differences between these views are probably grateful, and even those of us who merely occasionally sit in on such discussions might miss the thrust and parry, the move to the right followed by one to the left, that predictably emerge from these duels.

In many ways, molecules are now easier to study than biological populations, and nobody disputes the power of studying them to predict outcomes in isolated experimental systems. On the other side of the fence, those who want to understand how the world came to look the way it does point out that nothing in nature is in fact isolated—they seek multiple pathways of causation. But falling back on the platitude that everything is connected to everything else doesn't get anyone very far.

Happily, molecular technology can be married to the view from eternity, or at least the view from a landscape perspective. Some of the most creative strides in biology have been achieved by identifying where the very big engages with the very small. The article on landscape genetics that starts on p. 199, by Rolf Holderegger and Helene H. Wagner, describes a notable instance. The authors explain and set forth an agenda for what seems likely to become a key new frontier in the understanding of evolution. This article, the second in *BioScience*'s series on 21st Century Directions in Biology, shows how analytical techniques from landscape ecology as well as from molecular genetics are being combined in ways that could throw real-world evolutionary processes into unprecedented relief. Other researchers have similarly combined molecular biological data with surveys of ocean basins and lakes spread across continents.

Holderegger and Wagner survey methods for assessing not just the static spatial pattern of genetic variation, a staple of population genetics, but also how this pattern relates to landscape features and to the rate of flow of genes, even in organisms that cannot be radio tracked or marked and recaptured. When these approaches are focused specifically on adaptive genetic variation, by scanning genomes from organisms sampled in different circumstances, they are likely to yield crucial insights into how advantageous genes spread. One result could be a better understanding of the ways animal, plant, and microbial populations respond to habitat fragmentation and to climate change, dominant influences on biota worldwide.

Landscape genetics might thus in principle bring the predictive capability of molecular-scale research to studies that seek multiple causes and effects over geographic regions. This capability could be hugely important for intelligent planning of conservation efforts and for raising awareness of the awe-inspiring complexity of the ecosystems that support us. On this, even holists and reductionists can presumably agree.

TIMOTHY M. BEARDSLEY
Editor in Chief

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