

Disentangling Complexity in Biology

Author: Beardsley, Timothy M.

Source: BioScience, 60(5) : 327

Published By: American Institute of Biological Sciences

URL: <https://doi.org/10.1525/bio.2010.60.5.1>

BioOne Complete (complete.BioOne.org) is a full-text database of 200 subscribed and open-access titles in the biological, ecological, and environmental sciences published by nonprofit societies, associations, museums, institutions, and presses.

Your use of this PDF, the BioOne Complete website, and all posted and associated content indicates your acceptance of BioOne's Terms of Use, available at www.bioone.org/terms-of-use.

Usage of BioOne Complete content is strictly limited to personal, educational, and non - commercial use. Commercial inquiries or rights and permissions requests should be directed to the individual publisher as copyright holder.

BioOne sees sustainable scholarly publishing as an inherently collaborative enterprise connecting authors, nonprofit publishers, academic institutions, research libraries, and research funders in the common goal of maximizing access to critical research.

PUBLISHER
Richard T. O'Grady

EDITOR IN CHIEF
Timothy M. Beardsley

MANAGING EDITOR
Laura C. Sullivan

PEER REVIEW / EXTERNAL RELATIONS
Jennifer A. Williams

EDITOR
James Verdier

Editors: Eye on Education: Cathy Lundmark (educationoffice@aibs.org); Feature articles: Cathy Lundmark (features@aibs.org); Washington Watch: Robert E. Gropp (publicpolicy@aibs.org).

Editorial Board: Agriculture: Sonny Ramaswamy; Animal Behavior: Janice Moore; Animal Development: Paula Mabey; Botany: Kathleen Donohue; Cell Biology: Randy Wayne; Ecology: Scott Collins; Daniel Simberloff; Ecotoxicology: Judith S. Weis; Education: Gordon E. Uno; Environmental Microbiology: Rita R. Colwell; Environmental Policy: Gordon Brown, J. Michael Scott; Evolutionary Biology: James Mallet; Genetics and Evolution: Martin Tracey; History and Philosophy: Richard M. Burian; Human Biology: David L. Evans; Invertebrate Biology: Kirk Fitzhugh; Landscape Ecology: Monica Turner; Mammalogy: David M. Leslie Jr.; Microbiology: Edna S. Kaneshiro; Molecular Biology: David Hillis; Molecular Evolution and Genomics: David Rand; Neurobiology: Cole Gilbert; Plant Development: Cynthia S. Jones; Policy Forum: Eric A. Fischer; Population Biology: Ben Pierce; Professional Biologist: Jean Wyld; Remote Sensing and Computation: Geoffrey M. Henebry; Statistics: Kent E. Holsinger; Vertebrate Biology: Harvey B. Lillywhite.

BioScience (ISSN 0006-3568; e-ISSN 1525-3244) is published 11 times a year (July/August combined) by the American Institute of Biological Sciences, 1444 I Street, NW, Suite 200, Washington, DC 20005, in collaboration with the University of California Press. Periodicals postage paid at Berkeley, CA, and additional mailing offices. **POSTMASTER:** Send address changes to BioScience, University of California Press, Journals and Digital Publishing, 2000 Center Street, Suite 303, Berkeley, CA 94704-1223, or e-mail customerservice@ucpressjournals.com.

Membership and subscription: Individual members, go to www.aibs.org/individual-membership for benefits and services, membership rates, and back issue claims. Subscription renewal month is shown in the four-digit year-month code in the upper right corner of the mailing label. Institutional subscribers, go to www.ucpressjournals.com or e-mail customerservice@ucpressjournals.com. Out-of-print issues and volumes are available from Periodicals Service Company, 11 Main Street, Germantown, NY 12526-5635; telephone: 518-537-4700; fax: 518-537-5899; Web site: www.periodicals.com.

Advertising: For information about display and online advertisements and deadlines, e-mail adsales@ucpressjournals.com. For information about classified placements and deadlines, contact Jennifer A. Williams, AIBS (jwilliams@aibs.org).

Copying and permissions notice: Authorization to copy article content beyond fair use (as specified in sections 107 and 108 of the US Copyright Law) for internal or personal use, or the internal or personal use of specific clients, is granted by the Regents of the University of California on behalf of AIBS for libraries and other users, provided that they are registered with and pay the specified fee through the Copyright Clearance Center (CCC), www.copyright.com. To reach the CCC's Customer Service Department, call 1-978-750-8400 or e-mail info@copyright.com. For permission to distribute electronically, republish, resell, or repurpose material, and to purchase article offprints, use the CCC's Rightslink service on Caliber at <http://caliber.ucpress.net>. Submit all other permissions and licensing inquiries through the University of California Press's Rights and Permissions Web site, www.ucpressjournals.com/reprintinfo.asp, or e-mail journalspermissions@ucpress.edu.

Abstracting and indexing: For complete abstracting and indexing information, please visit www.ucpressjournals.com.

© 2010 American Institute of Biological Sciences. All rights reserved. Printed at Allen Press, Inc.

BioScience®

Organisms from Molecules to the Environment

American Institute of Biological Sciences

Disentangling Complexity in Biology

The discussion by Norman C. Ellstrand and his coauthors (p. 384) of the difficulties surrounding the regulation of hybrids serves as a reminder of how problematic biology becomes when it intersects with policy. Predicting how a biological system—ecosystem, organism, or something else—will behave is much harder than doing the same for a nonliving system, mainly because there are so many exceptions to generalizations about biology. Hybrids can have enhanced vigor and be persistent, or they can be weak, sterile, or both. Their occurrence can hasten the decline of a critically endangered species, or it can save a species. Genotype interacts with the environment to produce phenotype—but poorly understood epigenetic inheritance can substantially intervene. We understand the structure of the influenza virus at the atomic level, but we cannot say whether a mutant form will produce mass casualties until we start counting bodies. What is a policymaker to do?

It's not as if biology were afflicted merely with well-behaved, dependable, and quantifiable uncertainty. The growing focus on complexity in ecology is generating now-famous examples of sudden state changes—tipping points—that confound many attempts to foresee a system's response to a stimulus. Developmental biology affords similar examples. Interactions between genes and other factors are often sensitive to context, and random mutations continually alter that context. Things get only more complicated when one considers interactions between organisms, because most living things—including plants—influence the behavior of others. As for understanding how humans might settle their disagreements, science is still way behind artful diplomacy.

Does this recognition of biology's ornery nature make it less of a science than physics? No, says Sandra D. Mitchell, in a potentially important new book, *Unsimple Truths: Science, Complexity, and Policy* (University of Chicago Press, 2009). Mitchell argues persuasively for a pragmatic and conditional interpretation of what constitutes a scientific law. Even paradigmatic examples such as Galileo's law, which can be used to compute how far an object falls in a given period, are contingent on circumstances. What differentiates the laws of physics from those of biology is first and foremost the stability of the conditions upon which the causal relationship depends.

The laws of biology typically apply in more restricted domains than those of physics or chemistry, which should be no surprise. What is more, the emergent properties that arise in complex systems require biologists to be flexible in the types of measurements they use to establish useful laws, as some systems cannot be dismantled into modules with separable causal powers. "Some complex structures harbor nonmodular, context-sensitive actual causes that can explain their behavior," Mitchell states.

Far from being a counsel of despair, Mitchell's prescription, which she calls integrative pluralism, shows biologists how they can shed "physics envy." Though biological research presents challenges in terms of the amount of data that have to be analyzed, the computing power now available to researchers allows them to discern patterns that might have been invisible a generation ago. And biologists should be able to offer policymakers better tools than the cost-benefit analysis that underlies much of current policy. Biology may have awkward qualities, but it is not beyond science's power to manage them.

TIMOTHY M. BEARDSLEY

Editor in Chief

doi:10.1525/bio.2010.60.5.1