The Journal of Experimental Biology 215, 871

doi:10.1242/jeb.069575

EDITORIAL

Biophysics, bioenergetics and mechanistic approaches to ecology

In 1986, Tom Schoener evaluated the current state of community ecology, came to the conclusion that a reductionist approach to the subject was feasible (at least in theory) and proposed what he called 'a mechanistic ecologist's utopia' in which the dynamics of populations and communities could be predicted from information about the structure, physiology and behavior of individual organisms (Schoener, 1986). In the quarter of a century since Schoener's 'call to arms', his utopia has not been realized. The prevailing sentiment among ecologists has been that the mechanistic approach's immense informational requirements – and the complications inherent in synthesizing that information – put it beyond practical reach. Indeed, the extreme complexity of population and community dynamics has led some ecologists to question whether a mechanistic, predictive understanding of community ecology – elucidation of general laws – can ever be achieved (e.g. Lawton, 1999; Simberloff, 2004). This is a worrisome thought. In this time of rapid climate change (Intergovernmental Panel on Climate Change, 2007), it is discouraging to suppose that the complex nature of interactions among organisms – and among organisms and their environment – might preclude science from providing reliable guidance as to what the future has in store and how humankind should cope.

Recently, ecologists have begun to reconsider Schoener's proposition. Advances in technology have sparked optimism that the detailed information required for the mechanistic ecologist's utopia can actually be obtained. Using the wizardry of solid-state electronics, field ecologists can make measurements of physiology, behavior and the environment with an ease that could scarcely be imagined 25 years ago. Equally extraordinary advances in molecular biology allow physiologists, evolutionary and population biologists, and ecologists to explore the genetic underpinnings of their science in unprecedented detail. Similarly detailed environmental information is now readily available *via* remote sensing, and computing power has increased exponentially, making it practical for theoretical ecologists to manipulate models incorporating increased detail, even to the level of individual organisms. Based in part on this 'optimism of information', calls have gone out for new efforts to incorporate mechanistic understanding of individual organisms into the study of ecology (McGill et al., 2006; Kearney et al., 2008; Denny and Helmuth, 2009; McGill and Nekola, 2010; Monaco and Helmuth, 2011).

It is here that *The Journal of Experimental Biology* (JEB) enters the picture. Since its inception in the 1920s, JEB has championed development of mechanistic approaches to the study of physiology and biomechanics, research perspectives that use the tools of physics, chemistry and engineering to explain how individual plants and animals function. The time seems ripe to couple these mechanistic approaches (and the information already available at the individual level) to the efforts of population and community ecologists, forming a grand 'constructionist' perspective extending from genetics to ecosystems. Where might this marriage of mechanistic approaches be advantageous? Where is it even feasible? What areas of research need priority attention? These questions formed the impetus for a symposium on *Biophysics, Bioenergetics and Mechanistic Approaches to Ecology* held in Cambridge, UK in March 2011. The results are offered here.

No single volume could do justice to the multitudinous details of mechanistic approaches in ecology. Instead, what you will find in this compendium is a selection of topics that span the breadth of the subject. From the mechanics of individual molecules to the long-term viability of entire coral reefs. From ocean waves to waves of grain. From the genetic capacity for adaptation to the mechanics of reproduction and dispersal, to theories predicting evolved responses to rising temperature. Bacteria, phytoplankton and seaweeds; salmon and jellyfish; vultures, dragonflies, mussels and lizards; we have them all. The hope is that these articles will raise the awareness of JEB's traditional audience regarding the application of their interest and expertise to issues in ecology and that the topics addressed will raise the awareness of ecologists to the vast potential of mechanistic approaches.

A note about terminology. The combination of individual-level and ecological-level mechanistic approaches needs a name, and none of the traditional ones will do. 'Biophysics', 'bioenergetics' and 'biomechanics', while certainly part of the program, don't acknowledge ecology. 'Physiological ecology' and 'ecological physiology' traditionally do not emphasize the depth of physical and genetic detail espoused here. Instead, the term 'ecomechanics' [short for 'ecological mechanics' (Wainwright et al., 1976)] will be employed. As explained previously (Denny and Gaylord, 2010), the intent is not to exclude any field from a mechanistic approach to ecology but rather to provide a convenient shorthand for the whole broad perspective.

I thank the symposium participants and the editorial and production staff at JEB for their steadfast efforts, interest and good humor in bringing this special issue to fruition.

Mark Denny
Guest Editor

References

Denny, M. W. and Helmuth, B. (2009). Confronting the physiological bottleneck: a challenge from ecomechanics. *Intregr. Comp. Biol.* **49**, 197-201.
Denny, M. W. and Gaylord, B. (2010). Marine ecomechanics. *Annu. Rev. Mar. Sci.* **2**, 89-114.
Intergovernmental Panel on Climate Change (2007). *Climate Change 2007, The Physical Science Basis*. Cambridge: Cambridge University Press.
Kearney, M., Phillips, B. L., Tracy, C. R., Christian, K. A., Betts, G. and Porter, W. P. (2008). Modelling species distributions without using species distributions: the cane toad in Australia under current and future climates. *Ecography* **31**, 423-434.
Lawton, J. H. (1999). Are there general laws in ecology? *Oikos* **84**, 177-192.
McGill, B. J., Enquist, B. J., Weiher, E. and Westoby, M. (2006). Rebuilding community ecology from functional units. *Trends Ecol. Evol.* **21**, 178-185.
McGill, B. J. and Nekola, J. C. (2010). Mechanism in macroecology: AWOL or purloined letter? Towards a pragmatic view of mechanism. *Oikos* **119**, 591-603.
Monaco, C. J. and Helmuth, B. (2011). Tipping points, thresholds and the keystone role of physiology in marine climate research. *Adv. Mar. Biol.* **60**, 120-160.
Schoener, T. W. (1986). Mechanistic approaches to community ecology: a new reductionism? *Am. Zool.* **26**, 81-106.
Simberloff, D. (2004). Community ecology: is it time to move on? *Am. Nat.* **163,** 787-799.
Wainwright, S. A., Biggs, W. D. Currey, J. D. and Gosline, J. M. (1976). *Mechanical Design in Organisms*. London: Edward Arnold.