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The physics of evolution and biodiversity: Old answers to new questions, and more...

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In recent years there has been a contentious battle among prominent biologists about the validity of Kin versus Group Selection as models of evolutionary biology. I will show that the controversy is widely misunderstood and is rooted in the mean field basis of RA Fisher's statistical treatment of population biology, which is the origin of the "gene centered view"–kin selection and inclusive fitness–but is also often used in analysis of group selection. As in statistical physics, symmetry breaking and pattern formation, and their spatial realizations, result in breakdown of the mean field approximation and the widely believed mathematical 'proofs' of the universality of the gene centered view. Our simulation and analysis (http://necsi.edu/research/evoeco/) of the role of this breakdown in spatial ecology, biodiversity, speciation and altruism, suggest there is an entire field of new opportunities to explore in the implications for evolutionary theory. The difference between biodiversity of wildtype populations and narrowly homogeneous laboratory types manifest the self-consistency of theoretical assumptions and laboratory experiments performed under conditions in which the mean field approximation applies. In contrast, the highly diverse natural populations manifest the role of boundaries between types (hybrid zones), speciation by spontaneous clustering, and spatio-temporal dynamics in predator prey systems. Altruism arises in evolving populations due to the spontaneous dynamic group formation and the heritability of environmental conditions created by parents and experienced by offspring (niche construction with symmetry breaking), so that altruists are better able to survive over the long term than selfish variants. Many versions of the mean field approximation that are traditionally used eliminate these spatio-temporal processes, leading to false analytic conclusions about their impossibility. The traditional view of altruism influenced views also of individuals in their relationship to society. In addition to the basic reframing of the origin of altruism, the role of space in evolution has important implications for understanding global dangers today, including pandemics driven by evolution of virulent pathogens that escape death through long-range transportation, and economic or environmental overexploitation when globalization enables exploiters to escape the consequences of their actions. References: 1) Y. Bar-Yam, Dynamics of Complex Systems (Perseus Press, 1997) Chapter 6 http://www.necsi.edu/publications/dcs/ 2) Y. Bar-Yam, Formalizing the gene-centered view of evolution, Advances in Complex Systems 2, 277 (1999). 3) E. Rauch, H. Sayama, Y. Bar-Yam, Relationship between measures of fitness and time scale in evolution, Phys Rev Lett 88, 228101 (2002). 4) J. K. Werfel, Y. Bar-Yam, The evolution of reproductive restraint through social communication, PNAS 101, 11019 (2004). 5) E. M. Rauch, Y. Bar-Yam, Long-range interactions and evolutionary stability in a predator-prey system, Physical Review E 73, 020903 (2006). 6) C. Goodnight, E. Rauch, H. Sayama, M. A. M. De Aguiar, M. Baranger,Y. Bar-Yam, Complexity 13, 5, 23 (2008) 7) M.A.M. de Aguiar, M. Baranger, E.M. Baptestini, L. Kaufman, Y. Bar-Yam, Global Patterns of Speciation and Diversity, Nature 460, 384 (2009). 8) B. C. Stacey, A. Gros, Y. Bar-Yam, Beyond the Mean Field in Host-Pathogen Spatial Ecology. arXiv:1110.3845, October 5, 2011 9) G. Wild, A. Gardner, S. A. West, Adaptation and the evolution of