Experimental Measurement of Information-Content in Mutational Ensembles

F. Ritort[*,**]

*Small Biosystems Lab, Condensed Matter Physics Department, Faculty of Physics, University of Barcelona, Carrer Martí i Franques 1, 08028 Barcelona (Spain)
** Institut de Nanociència i Nanotecnologia (IN2UB), Universitat de Barcelona, 08028 Barcelona, Spain

Abstract.

Biology is noisy at all levels, from molecules to cells, tissues, organs, communities, and ecosystems [1]. While thermodynamic processes in the ordinary matter are driven by free-energy minimization, living matter delineates a fascinating evolutionary state governed by information flows across all organizational levels [2]. While we know how to measure energy and entropy in physical systems, we have poor general knowledge about measuring information content. Recent developments in stochastic thermodynamics of feedback systems and single-molecule experiments [3,4] show that information content equals free energy differences between disordered populations. A fluctuation theorem for mechanical work and information content is applied to a mutational ensemble of DNA hairpin folders with different base pair mutations. The thermodynamic information-content correlates but is higher than the Shannon entropy of the mutational ensemble.

1. F. Ritort, *The noisy and marvelous molecular world of biology,* Inventions, **4**(2) (2019) 24
2. T. Dobzhanski, F. J. Ayala, G. L. Stebbins & J. W. Valentine, *Evolution,* W. H. Freeman, 1977
3. M. Ribezzi-Crivellari and F. Ritort, *Large work extraction and the Landauer limit* in the *Continuous Maxwell Demon,* Nature Physics **15** (2019) 660–664
4. M. Rico-Pasto, R. K. Schmitt, M. Ribezzi-Crivellari, J. M. Parrondo, H. Linke, J. Johansson and F. Ritort, *Dissipation reduction and information-to-measurement conversion in DNA pulling experiments with feedback,* Physical Review X **11** (2021) 031052