Universal Biology in Adaptation and Evolution: Dimensional Reduction, and Fluctuation-Response Relationship

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A macroscopic theory for cellular states with steady-growth is presented, based on consistency between cellular growth and molecular replication, together with robustness of phenotypes against perturbations. Adaptive changes in high-dimensional phenotypes are shown to be restricted within a low-dimensional slow manifold, from which a macroscopic law for cellular states is derived, as is confirmed by adaptation experiments of bacteria under stress. The theory is extended to phenotypic evolution, leading to proportionality between phenotypic responses against genetic evolution and by environmental adaptation, which explains the evolutionary fluctuation-response relationship previously uncovered. Relevance of statistical-physics and dynamical-systems approach is discussed.

References

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