Colloquium

MAX PLANCK INSTITUTE
FOR DYNAMICS AND
SELF-ORGANIZATION

Dimensional Reduction, Evolutionary Fluctuation-Response Relation and Homeorhesis in Adaptation, Evolution, and Development

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Life systems are complex and hierarchical, with diverse components at different scales, yet they sustain themselves, grow and evolve over time. Here we note that for a hierarchical biological system to be robust, it must achieve consistency between micro-scale (e.g. molecular) and macro-scale (e.g. cellular) phenomena, which allows for a universal theory of adaptive changes in biological systems. The talk will present a demonstration of how adaptive changes in high-dimensional phenotypes (biological states) are constrained to low-dimensional manifold, leading to a macroscopic law for cellular states, as confirmed by adaptation experiments of bacteria. The theory is then extended to evolution, leading to an evolutionary fluctuation-response relationship that shows the proportionality between phenotypic changes due to environmental adaptation and genetic changes. This finding allows the prediction of evolution, as demonstrated experimentally. Finally, we extend this theory to the development of multicellular organisms, and discuss how irreversible cell differentiation and the robustness of developmental pathways (homeorhesis) are acquired. Overall, this talk highlights the potential for physics to the study of biology through a universal perspective and the development of macroscopic theories for living systems.

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Maria Goeppert room (0.79) and
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