



**Politecnico  
di Torino**

Dipartimento  
di Ingegneria Meccanica  
e Aerospaziale



## DIMEAS SEMINAR

# DIRECTIONALITY THEORY AND THE ORIGIN OF CELLULAR LIFE

## SPEAKER



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10 am**



**Sala Ferrari, II floor,  
DIMEAS – Politecnico di Torino**

### Abstract

The origin of cellular life can be described in terms of the transition from inorganic matter to the emergence of cooperative assemblies of organic matter: RNA, protein, DNA. Directionality theory is a mathematical theory of the collective behaviour of networks of organic matter: activated macromolecules, cells and higher organisms. Evolutionary entropy, a generalization of the Thermodynamic entropy of Boltzmann, is a statistical measure of the cooperativity of the components of organic matter. The cornerstone of Directionality theory is the Fundamental Theorem of Evolution: Evolutionary entropy increases in systems driven by a stable energy source, and decreases in systems driven by an unstable energy source. I will invoke the Fundamental Theorem of Evolution—an extension to biological systems of the Second Law of Thermodynamics—to provide an adaptive rationale for the origin of cellular life: The integration of the three carbon-based polymers—DNA, proteins and lipids, to generate a metabolic and replicative unit.

### BIO

Lloyd A. Demetrius is an American mathematician and theoretical biologist currently affiliated with the Department of Organismic and Evolutionary Biology at Harvard University. He is widely recognized for his discovery of the concept of evolutionary entropy, a statistical parameter that characterizes Darwinian fitness across biological organization levels and serves as the cornerstone of directionality theory, an analytical framework for evolution driven by variation and selection. His work extends classical thermodynamic ideas into evolutionary biology, with applications ranging from aging and longevity to the progression of age-related diseases and the evolution of cooperation and social inequality. Demetrius earned his undergraduate degree in mathematics from the University of Cambridge and his PhD in mathematical biology from the University of Chicago. Over his career he has held faculty and research positions at multiple institutions, including the University of California, Berkeley, Brown University, Rutgers, and the Max-Planck Institutes, before joining Harvard.