



The Thermodynamic Machinery of Life (The Frontiers Collection)

By Michal Kurzynski

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Thermodynamics was created in the first half of the 19th century as a theory designed to explain the functioning of heat engines converting heat into mechanical work. In the course of time, while the scope of research in this field was being extended to a wider and wider class of energy transformations, thermodynamics came to be considered as a general theory of machines identified with energy transducers. Important progress in biochemistry in the first half of the 20th century, and in molecular biology in the second half, made it possible to think of treating even living organisms as machines, at least on the subcellular level. However, success in applying thermodynamics to elucidate the phenomenon of life has been rather mitigated. Two reasons seem to be responsible for this unsatisfactory situation. Nineteenth century thermodynamics dealt only with simple (homogeneous) systems in complete equilibrium. Although during the 20th century a nonequilibrium thermodynamics was developed, starting with the Onsager theory of linear response and ending with the Prigogine nonlinear theory of dissipative structures, these theories still concern the originally homogeneous systems. Because living organisms are complex systems with a historically frozen spatial and functional structure, a thermodynamics of both nonequilibrium and complex systems is needed for their description. The first goal of the present book is to formulate the foundations of such a thermodynamics.

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Editorial Review

Review

From the reviews:

“The book seamlessly presents the historical and philosophical evolution of a fundamental principle ... and develops the implications of the principle in a staggeringly wide range of contexts. ... a work that is engaging, lucid and supremely approachable. ... the warmth and sincerity of the writing make this book a joy ... Highly recommended.” (Philosophy, Religion and Science Book Reviews, bookinspections.wordpress.com, May, 2014)

From the Back Cover

Living organisms are open thermodynamic systems whose functional structure has developed and been kinetically frozen during the historical process of biological evolution. A thermodynamics of both nonequilibrium and complex systems is needed for their description. In this book, the foundations of such a thermodynamics are presented. Biological processes at the cellular level are considered as coupled chemical reactions and transport processes across internal and the cytoplasmic membrane. All these processes are catalyzed by specific enzymes hence the kinetics of enzymatic catalysis and its control are described here in detail. The coupling of several processes through a common enzyme is considered in the context of free energy or signal transduction. Special attention is paid to evidence for a rich stochastic internal dynamics of native proteins and its possible role in the control of enzyme activity and in the action of biological molecular machines.

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