Determining Mechanisms of Complex Chemical and Biological Processes Using Networks Analysis

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Almost all chemical and biological processes can be viewed as complex networks of discrete chemical states connected by dynamic transitions. It is fundamentally important to determine the structure of these networks in order to fully understand mechanisms of underlying processes. A new model-free theoretical method of determining mechanisms and dynamic properties of complex chemical and biological processes, which utilizes a first-passage analysis, is developed. Our approach is based on the idea that full temporal distributions of events between two arbitrary states, which is the outcome that most frequently measured in experiments, contain full information on the dynamics of the system. Using a separation of time scales, it is shown that important aspects of the mechanisms of chemical and biological processes can be easily determined. Our theoretical approach is illustrated on several biological systems.