THE RELEVANCE OF MAXIMUM ENTROPY PRODUCTION PRINCIPLE AND MAXIMUM INFORMATION ENTROPY PRINCIPLE IN BIOLOGY

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We start this talk posing the question, is there any physical principle that can serve as a selection principle in biology too?

One of the first undertakings in this direction, conducted by Prigogine and Wiame [1] noticed correctly that biological processes are irreversible and as such should be described within irreversible thermodynamics. Since irreversible processes are characterized by entropy increase, they took the entropy production as the basic quantity for the description of biological processes and introduced the concept of dissipative structures. Prigogine suggested the principle of minimum entropy production (MinEP) [2] as a relevant principle for the biology, but the MinEP theorem describes the static head steady state, close to equilibrium state, when output flux and free-energy-transduction efficiency both vanish, an unrealistic and untenable situation for complex hierarchy of energy transductions in biological systems.

Another principle is maximum entropy production (MaxEP) principle, which assumes that biological processes are accompanied by maximum possible entropy production. It looks like the antipode of the minimum entropy production principle. However, as it was stressed by Martyushev and Selzev [3], these two principles should not be considered as contradictory or opposed to each other, since they include different constraints and different variable parameters. We argue here that MaxEP principle is more suitable than MinEP principle for a description of energy transduction in biological systems.

There are two different approaches to MaxEP. Some authors assume that MaxEP can be derived from more fundamental principle. The most prominent author within this group is R. Dewar who made several attempts [4-6] to derive MaxEP from Jaynes' principle of maximum information entropy (MaxEnt). Another group assumes that the MaxEP principle is the fundamental one, which does not require some underlying principle as its foundation [3].

E. T. Jaynes, starting from Shannon information theory, launched the MaxEnt principle as universal principle which predicts the best unbiased distribution of [7,8].

Our basic assumption is that the biological evolution of basic biochemical processes, like photosynthesis [10], free-energy transduction of ATP synthase [11] and catalytic cycle fluxes among enzyme internal functional states [12,13] is accompanied by an entropy production increase and with the Shannon’s information entropy increase of enzyme states. In such a way the increase of entropy production is understood as being tightly coupled to biological evolution. We do not offer the MaxEP principle as an alternative to biological selection and evolution. Rather, it is the unique physical selection principle [9] which can be regarded as a good candidate for acting in concert with biological selection and evolution.