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Driving early biochemical reactions by the thermal accumulation of ATP over ADP/AMP?

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Introduction: Life is a non-equilibrium system. The energy required to maintain an organism out of equilibrium is provided by bio-molecules such as ATP. While the synthesis of such energy-rich molecules is nowadays aided by light, this has not been possible in a prebiotic environment. Back then, prebiotic gradients might have enabled a chemical driving of the non-equilibrium. Interestingly, a simple thermal gradient is capable of accumulating ATP over ADP/AMP due to the charge difference. The system delivers a ratiometric excess of ATP utilizing a prebiotically available mechanism and can locally drive biological reactions. With this hypothesis, we can allow previously studied thermal replication and selection systems [1,2] to use ATP as the energy currency of its biochemical reactions. No highly evolved and complex ATP synthase would be necessary for life in its first steps.

Another relevant example is RNA polymerization, which must have been a crucial element at life's early stages but can only operate at sufficient NTP levels. Experimentally, we feed the thermal trap with a close to equilibrium concentration ratio of ATP and ADP. The local accumulation of the energy-rich species is monitored by the fluorescent protein PercevalHR [3].

In conclusion, we propose a system which uses the prebiotically realistic thermal trap to locally shift the equilibrium of ADP and ATP towards an ATP bias and thereby allows biochemical reactions to take off.

References:

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