

Does Life Use Energy? E. Branscomb¹ and M. Russell², ¹Carl Woese Institute for Genomic Biology, 1206 W Gregory Dr, Urbana, IL 61801; brnscmb@illinois.edu, ² Jet Propulsion Laboratory, California Institute of Technology, 183-601, 4800 Oak Grove Dr., Pasadena, CA, 91109-8001.

A notable and distinguishing feature of the alkaline hydrothermal vent (AHV) theory for the emergence of life [1-3] is the dramatic extent to which it implies a strict and detailed continuity between the abiotic devices that engendered life and the most conserved, fundamental and universal metabolic mechanisms of extant life, those of energy metabolism in particular. Most striking in this overall picture is the role of a transmembrane proton gradient in powering those essential reactions of life that must be thermodynamically driven. In the AHV theory, the proton gradient, 'biological' in both strength and direction, along with the needed 'membranes', gradient-driven conversion engines (e.g., functional analogues of ATP synthase), appropriate confinements, and appropriately caged transition-metal catalysts, were supplied abiotically and 'for free'; by the geochemical process of serpentinization – a characteristic of wet, rocky, tectonically active planets. Much else in life's universal energy metabolism strategies was served up by this mechanism as well. All of it serving, however, then and now, one specific type of thermodynamic function: that of 'driving' specific processes away from equilibrium rather than allowing them to rest at, or relax towards, equilibrium – processes such as fixing carbon starting from CO₂, fixing nitrogen starting from nitrate, forming pyrophosphate from orthophosphate, etc. Thus the AHV theory implies that to understand life's emergence, and to know what to look for in seeking evidence for it elsewhere in the universe, we need to understand in molecular-level detail how endergonic, thermodynamically 'uphill' processes of the relevant types are made to happen, whether biotically or abiotically. But here we encounter a conceptual stumbling block; contrary to essentially all received wisdom, endergonic processes are not driven by, and therefore life itself is not powered by, the consumption of energy (even of the 'free part' of an energy). Therefore, among other implications, the quest, whether for understanding or for sites, is not for 'sources of energy'. The talk will summarize the case for this claim, attempt to clarify how living systems are in fact powered, and explain why the issue is important in the search for life.

References:

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[3] Russell M. J., Barge L. M., Bhartia R., Bocanegra D., Bracher P. J., Branscomb E., et al. (2014) *Astrobiology*;14(4):308–343.