

An Energy Criterion for Habitability

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The concept of habitability offers a means of constraining the possible distribution of life in any system, and can thereby greatly aid in narrowing the field of possible targets in astrobiological search strategies. Energy is fundamentally required by all life, and its availability therefore represents a potential constraint on habitability. For terrestrial life, this conceptual constraint takes the form of a quantitative boundary condition, because the nature (and unity) of our biochemistry imposes shared and discrete minimum requirements on the levels and flux of energy that can be biologically exploited. This boundary condition applies in principle to both light and chemical energy sources. While seldom tested in the terrestrial surface biosphere, these requirements can be significant in comparison to the rates and levels at which subsurface geochemical processes can liberate energy in useful forms. “Energetic habitability” may thus be among the most important factors constraining the potential distribution of life in subsurface environments, and therefore carries particular significance for the astrobiology of Mars, Europa, and even the Earth during potential periods of uninhabitable surface conditions. If the factors underlying the existence of biological minimum energy requirements are not specific to terrestrial biochemistry, but fundamental to chemical life in general, the energetic habitability concept would represent a broadly applicable criterion in the search for extraterrestrial life.