Energy limits on microbial life: growth, maintenance, persistence

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The bulk of microbial activity in natural environments can be assigned to one of three states: 1) growth, 2) maintenance or 3) persistence. In addition to nutrients and water, the main factor determining the specific state occupied by the majority of a microbial population is the amount of available energy. That, in turn, is a function of environmental variables such as temperature, pressure, pH and chemical composition, which can readily be quantified for just about any environment using equations of state and thermodynamic data reported in the literature. However, determining how much energy microorganisms require to grow, maintain or persist in natural settings is not well understood. The purpose of this study is to put quantitative limits on the boundaries between these metabolic states. Because energy demand, like supply, is a function of environmental conditions, there is no singular energy value that characterizes one metabolic state from another. For example, the amount of energy required to synthesize all the biomonomers that comprise a prokaryotic organism varies from about 18 to 1.4 kJ (g cells)$^{-1}$ depending on the oxidation state of the environment [1].

In this study, we establish methods for quantifying the energy required to synthesize new biomass (including biomacromolecular polymerization, 0.3 kJ (g cells)$^{-1}$), delineate the rate at which energy is needed for maintenance for a diverse set of metabolisms (varying over 5 orders of magnitude), compute the power needed to prevent cellular decay and compare these values to the power supplied in low-energy environments (deep marine sediments). Since energy demand is a function of time, results are reported in terms of power (Watts).

[1] Mccollom T.M. and Amend J.P. (2005) *Geobiology* **3**, 135-144.