Optimization - thermodynamic and otherwise

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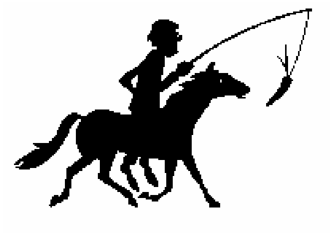
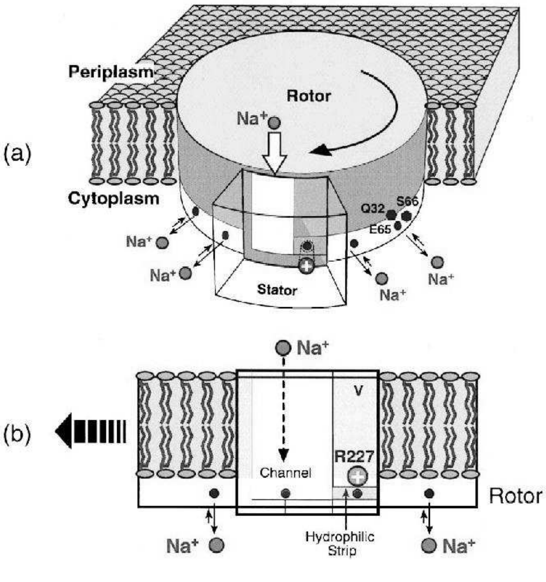
We all strive to do our tasks as efficiently as possible. In thermodynamics Carnot's law puts an upper limit on the fraction of a heat source which can be converted into work, $\eta_C=(T_H-T_L)/T_H$. In statistical mechanics systems rearrange so as to maximize their entropy. In evolution organisms mutate and the fittest survive. In mathematics the maximum or minimum of a function y(x) is found where dy/dx=0.



We let these approaches inspire one another and have optimized the design and operation of engines, refrigerator systems, solar converters, coupled chemical reactions, distillation columns, information transmission, market trading, and others. In all cases the optimum is found where the system is gradually coached along by its environment rather than forced to make a single large jump, much like this horse.

Along the way the original thermodynamic and statistical mechanical optimization results inspired improvements of general optimization methods like simulated annealing. Length calculations in a new abstract space, thermodynamic geometry, allow tighter bounds on efficiency than Carnot did, including the duration of the process, and may specify the optimal process path.

Currently we optimize the operation of large scale distillation columns and search for ways to construct heat pumps which deliver their output over a range of temperatures, e.g. by using fluid mixtures as working fluids. More abstract issues include training neural networks using simulated annealing and comparing the performance of different optimization methods, e.g. simulated annealing against genetic algorithms and extremal optimization. The statistically founded bounds and optimal paths are a direct invitation to "check" whether Nature goes about operating its small biological systems like the cytochrome chain in mitochondria, producing the universal energy packets ATP for running the cell, and molecular ratchets and motors like this one in an optimal fashion.



An important optimization problem is the "best" design of mirrors, e.g. for light sources and light collectors. Complicated proprietary algorithms have been developed for this purpose, but couldn't the statistically founded simulated annealing do the job? Finally, have you ever wondered why it is obvious from equal size pictures of two animals to see which one is the larger? Body proportions as well as metabolism scale non-linearly with size, and this may be argued theoretically.

Basically I enjoy developing methods and see them applied to as varied examples as possible. Inspired young input is always a delight.