CHE 498 DIRECTED RESEARCH Fall 2005

Project 4: Simple inorganic systems exhibiting far-from-equilibrium behavior.

In elementary chemistry classes we deal mostly with situations at or approaching chemical equilibrium. At equilibrium, the Gibbs free energy *G* is at a minimum (and ceases to change). However, all of biology takes place in systems which are very far from equilibrium, and the fact that such systems are far from equilibrium is a key requirement for pattern formation. In a biological cell, for example, materials flow in and out through the cell membrane, and overall the cell – as long as it is alive – steadily dissipates energy and increases the level of entropy in its surroundings.

Systems that do not tend to equilibrium can exhibit interesting and complex behavior, including cyclic time-dependence and wavelike spatial structures [1]. Recently, for example, a simple inorganic chemical system (copper-doped calcium chloride in a solution of sodium carbonate, sodium iodide, and hydrogen peroxide) was observed to generate "cellular" structures enclosed in a semipermeable membrane and sustaining catalytic chemical reactions in their interior [2]. The initial report of this work was somewhat brief, and further work is certainly required for a better understanding of this and similar systems. For example, theories of the origin of life include some in which life originates in inorganic systems and is subsequently "copied" to organic systems *via* a molecular template [3]; this phenomenon may be of relevance to such theories.

Our goal in this project is to reproduce this work and extend it, developing methods of tracking "cell" growth and chemical composition and of following the temperature-dependence and composition-dependence of the behavior of related systems.

<u>Initial references:</u>

1. See e.g. Prigogine, I., *From Being to Becoming – Time and Complexity in the Physical Sciences*, Freeman, 1980.
2. Maselko, J., and Strizhak, P., *J. Phys. Chem. B* **108** (2004), 4937.
3. See e.g. Cairns-Smith, A. G., *Seven Clues to the Origin of Life – A Scientific Setective Story*, Cambridge, 1985.