Cells, Gels and the Engines of Life: A Fresh Paradigm for Cell Function

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The cell cytoplasm is broadly acknowledged to be a polymer gel. Textbook mechanisms nevertheless build on the presumption that it is an aqueous solution. Gels and aqueous solutions are quite different: Gels are polymer matrices to which water clings—that's why the cracked egg feels gooey, and why gelatin dessert does not shrivel up despite 95% water content. The concept of a gel-like cytoplasm is replete with power. Partitioning of ions between the inside and outside of the cell is directly explainable from the cytoplasm's gel-like character and the organization of its water molecules; such partitioning requires zero maintenance energy, unlike ion-pumping mechanisms. The cell's electrochemical potential is also explainable: substantial potentials are measured in gels, as well as in cells stripped of their membrane.

Gels also undergo phase-transition—transformation from one physical state to another. In so doing, they change volume, ion content, solvency, permeability, etc.—changes similar to those experienced by organelles within the functioning cell. Each organelle is effectively a nanogel, which can undergo phase-transition from one state to another to carry out its assigned task. The polymer-gel phase transition therefore has the potential to be a central paradigm for mediating many aspects of cell function.

These ideas are explored in depth in a recent book (Pollack, "Cells, Gels and the Engines of Life," 2001, www.ebnerandsons.com), and will be presented at the lecture.