# Cell Structures Exhibit Novel Behaviors, Mimic Red Blood Cells and Liquid Crystals

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Researchers at the University of Pennsylvania and Yale University have manipulated the internal, structural components of cells, creating a set of simulated cellular structures with novel mechanical properties, including one that acts like a red blood cell and another that mimics the soft, elastic behavior commonly found in novel synthetic materials called liquid crystal elastomers.

The findings point to nature's innate ability to create a variety of cell structures and behaviors using standard cell proteins and to science's potential to construct new classes of material by manipulating cell cytoplasm.

In a study reported online this month in *Nature Physics*, researchers fortified actin filament networks, the protein components in cell cytoplasm that help form the skeleton and the cell's capacity for movement, with protein crosslinks of varying length and elasticity.

"The resulting cell structures exhibited a number of novel and useful physical properties, depending upon the length of the filaments that formed the cell network," Dennis Discher, professor of biological engineering at Penn, said.

Those with very short actin filaments and long crosslinkers resemble the cytoskeleton of the red blood cell and remain isotropic, that is, maintain their shape under compression and shear. Since blood cells in blood flow experience hydrodynamic stresses from all directions, the isotropic properties of the simulated cells are well suited to the fluid stresses of blood flow.

Networks with longer filaments, which occur naturally in many types of animal cells, demonstrate different behavior. Loose networks with long crosslinkers are isotropic at zero stress, yet align under compression or shear, allowing these cells to adjust their cytoskeleton to the stresses in the environment. Such cell structures can be moved, or directed, as cells adjust to their surroundings.

"Semi-loose" networks have somewhat shorter crosslinks and are nematic, or thread-like at low stress, but become isotropic under dilation. "Tight" networks possess a locked-in nematic orientation, much like the cytoskeleton of the outer hair cell in the ear. This cell is responsible for the amplification of sound, and the oriented cytoskeleton helps direct sound propagation from the ear canal to the receiving neuron that interfaces to the brain.

A subset of the simulated cells, those with periodic crosslinks, demonstrate an especially unique type of super-soft behavior recently found in liquid crystal elastomers. Synthetic materials of this type have properties typified in liquid crystal displays but also the flexibility of highly elastic materials, such as latex gloves. The biologically based results highlight the fact that nature probably "did it first," and the results point the way towards the creation of new materials with novel optical, thermal and electrical properties.

The study was conducted by Discher, of Penn's School of Engineering and Applied Science, as well as Tom Lubensky, chair of Penn's Department of Physics and Astronomy in the School of Arts and Sciences, and Paul Dalhaimer of the Department of Molecular, Cellular and Developmental Biology at Yale University.

Source: University of Pennsylvania