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SPECIAL ISSUE PREFACE

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Tribute to H. Eugene Stanley

This issue of the *Journal of Physical Chemistry B* is dedicated to H. Eugene (Gene) Stanley, William Fairfield Warren Distinguished Professor and Professor of Physics, Chemistry, Biomedical Engineering, and Physiology at Boston University. The scope of Gene Stanley's research accomplishments is virtually unparalleled in the physical sciences. In more than 1000 publications, he has made groundbreaking contributions to the fundamental understanding of phase transitions, critical phenomena, polymers, biological materials, protein aggregation, the statistics of DNA sequences, econophysics, granular materials, physical and social networks, and especially supercooled and glassy water. With nearly 48,000 citations to his journal articles (109 of them with more than 109 citations) and over 8000 citations to his books, Gene's work has had enormous impact across many fields of science.

Gene's contributions in condensed matter theory include his important early work on the two-dimensional Heisenberg ferromagnet[1] and the spherical model,[2] as well as subsequent fundamental studies of percolation[3] and dendritic crystal growth.[4] He has fruitfully applied scaling concepts that underlie the theory of critical phenomena to biology, discovering long-range correlations in noncoding nucleotide sequences in DNA[5] and long-ranged anticorrelations in sequences of human heartbeats;[6] to economic systems, showing that the dynamics of the Standard & Poor's 500 economic indicator can be described as a Lévy stable process;[7] and to medicine, demonstrating scaling behavior in the size distribution of neuropathological lesions in Alzheimer disease.[8] His work on networks, both physical and social, has led to deep insights on topics ranging from the web of human sexual contacts[9] to urban growth patterns[10] and from the general scaling properties of networks[11] to the catastrophic failure of power grids.[12]

Along with a select group of scientists including Austen Angell, Osamu Mishima, and the late Erwin Mayer, Gene has helped to define the boundaries of contemporary knowledge on metastable water at low temperatures. In more than three decades of pioneering work, he has been the originator of the picture of water as a transient gel, and of the liquid−liquid phase transition hypothesis for the phase behavior of cold, metastable water. Because of water's unique importance, this body of work has far-reaching implications in biology, astrophysics, materials science, and the technology of low-temperature preservation of biological molecules. In 1979, Gene proposed a model that has had lasting impact on the understanding of supercooled water.[13] In this model, correlations between density, energy, and entropy fluctuations arising from the formation of hydrogen bonds give rise, at low temperatures, to anomalous increases in the response functions, such as those observed experimentally in supercooled water. This model, which was subsequently discussed in detail in a now-classic paper with José Teixeira,[14] provided the first molecular-based interpretation of the anomalous properties of supercooled water (sharp increase of response functions upon cooling), which had been discovered by Angell and co-workers a few years before. For more than a decade, the Stanley−Teixeira correlated site percolation model, together with Speedy's stability-limit conjecture[15] set the terms of the debate on the interpretation of supercooled water's thermodynamic behavior.

In a series of highly influential papers beginning in 1992, Gene and his co-workers proposed the fascinating hypothesis that, at sufficiently low temperatures, pure water phase-separates into two distinct forms. According to the liquid−liquid phase transition hypothesis, the two low-temperature phases are the liquid analogues of the two experimentally observed distinct glassy phases of water, known as LDA (low-density amorphous ice) and HDA (high-density amorphous ice).[16] Two papers from among this body of work deserve special mention: the 1992 molecular dynamics study of supercooled and glassy water, where the liquid−liquid transition hypothesis was first formulated,[17] and the 1998 paper with Mishima,[18] which, in a veritable experimental *tour de force* (measuring the metastable melting curve of a high-pressure polymorph of ice), provided evidence consistent with the liquid−liquid transition hypothesis.

The liquid−liquid phase transition hypothesis remains a subject of active inquiry and vigorous debate. In addition to providing a plausible (but not proved) interpretation of experimental observations on supercooled and glassy water, it has also opened up an entirely new field of research, which has come to be

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known as liquid polyamorphism. This refers to the possibility of first-order phase transitions between disordered phases in pure liquids. According to this viewpoint, the observed phase transition between LDA and HDA is the structurally arrested manifestation of an underlying equilibrium liquid−liquid transition between two distinct forms of liquid water. The implications of this hypothesis are truly far-reaching, and have had a major impact on theoreticians and experimentalists interested in the liquid and vitreous states of matter.

In addition to his influence as a creative scientist, Gene has had an enormous impact on the education of generations of physicists, chemists, and engineers, who have learned about phase transitions through his classic book "*Introduction to Phase Transitions and Critical Phenomena*".[19] Cited more than 3700 times, this book remains, forty years since its writing, an unusually clear, elegant, and informative introduction to this vast and foundational topic. Gene has coauthored several other books, on topics ranging from fractal forms to an introduction to theoretical physics, attesting to his passion for the transmission, as much as for the creation, of knowledge.

No account of Gene Stanley's accomplishments would be complete without mentioning his extraordinary qualities as a caring and supportive mentor of the more than 80 students who have completed their Ph.D. thesis under his supervision, his unique ability to establish fruitful collaborations and lasting friendships with scientists from across the world, his tireless support of women in science, and his lifelong dedication to human rights. These aspects of Gene's work were recognized through the American Physical Society's 2003 Nicholson Medal for Human Outreach.

Gene Stanley's research accomplishments have earned him numerous honors. Three among them merit special mention: the International Union of Pure and Applied Physics' Boltzmann Medal (2004), his election to the National Academy of Sciences (2004), and the American Physical Society's Lilienfeld Prize (2008). In addition, he is the recipient of *Honoris Causa* Doctorates from Bar-Ilan University, Eötvös University, the University of Dortmund, the University of Liege, Wroclaw University, Northwestern University, and the University of Messina. This volume, for which we are privileged to serve as Guest Editors, honors Gene Stanley on the happy occasion of his 70th birthday.

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