Editorial: Soft Matters

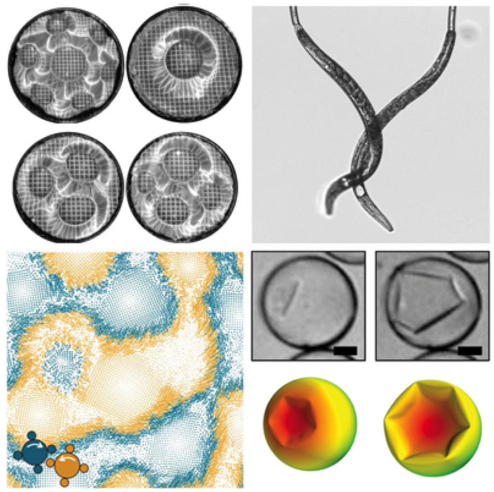

FIG. 1 (color online). Examples of soft matter systems. (a) Gravity driven instabilities in polyacrylamide gels (adapted from [19]). (b) Two tangled *C. elegans* worms (reproduced from [20]). (c) Phase separation of clockwise and anticlockwise rotating spinners (adapted from [21]). (d) Optical microscope images (top) and simulations (bottom) of colloidal capsules buckling under external osmotic pressure (adapted from [22]).

In 1991, French scientist Pierre Gilles de Gennes received the Nobel Prize in Physics "for discovering that methods developed for studying order phenomena in simple systems can be generalized to more complex forms of matter, in particular to liquid crystals and polymers" [1]. Now credited as the "father" of soft matter, de Gennes showed how disparate problems at the interface of physics, chemistry, and biology share many key features, and can be treated with similar approaches borrowed from statistical mechanics and thermodynamics [2]. At that time a relatively small but vibrant branch of physics, distinct from hard condensed matter, soft matter encompassed "squishy" materials like polymers and biopolymers, foams, liquid crystals, complex fluids, and membranes.

Less than three decades on, soft matter has burgeoned to include seemingly unrelated topics such as patchy particles [3,4], DNA assemblies [5], and granular packings [6,7]. Origami-inspired materials [8,9] and self-propelled colloids [10,11,12] are hot topics studied by soft matter scientists worldwide. No longer confined to "squishy" systems, it's the puzzles posed, the questions asked, and the tools used to address the problem that make it soft.

Soft matter problems are challenging and messy due to their many-body nature, the importance of interactions across many length and time scales, the existence of metastable states, their often complex geometry and topology [13], and long relaxation times [14]. Active matter [15], where materials are driven out of equilibrium through the input of energy, challenges standard statistical mechanical treatments despite exhibiting emergent, self-organized phenomena similar to that seen in thermodynamic systems [16]. This has become a fast growing subset of soft matter [17].

Inherently, soft matter is interdisciplinary, bringing together chemists, material scientists, chemical engineers, applied mathematicians, mechanical engineers, and, of course, physicists. This enables scientists working in this field to bring a range of experiences, viewpoints, and approaches that together provide vitality and accelerate progress. Soft matter not only spans professional societies, but also permeates many different APS units and the Physical Review journals. Recognizing this, a new APS Topical Group on Soft Matter (GSOFT) [18] was formed in 2014 as a "home" for soft matter. With well over 1300 signatures, the petition to form GSOFT received broad, enthusiastic support across the APS. Debuting at the upcoming 2015 March meeting in San Antonio, GSOFT is sponsoring and co-sponsoring over 700 presentations, with focus or invited sessions on topics including swimmers, reconfiguring and actuating soft matter, jamming in granular media, and soft matter nanophotonics.

0031-9007/15/114(5)/050001(2)

New materials, technologies, and medical breakthroughs rely on continued discoveries and innovation in soft matter. With more young physicists going into soft-matter related fields than ever before, this is indeed an exciting time for our community.

Sharon C. Glotzer
Departments of Chemical Engineering,
Materials Science & Engineering,
Physics, Applied Physics, and
Macromolecular Science & Engineering,
University of Michigan,
Ann Arbor, Michigan 48109, USA

Published 2 February 2015
DOI: 10.1103/PhysRevLett.114.050001
PACS numbers: 01.30.Ww

[1] P. G. de Gennes, Nobel Lecture in Physics in 1991, http://www.nobelprize.org/nobel_prizes/physics/laureates/1991/gennes-lecture.pdf.
[2] P. G. de Gennes, Soft matter, Rev. Mod. Phys. **64**, 645 (1992).
[3] Z. L. Zhang and S. C. Glotzer, Self-assembly of patchy particles, Nano Lett. **4**, 1407 (2004).
[4] E. Bianchi, J. Largo, P. Tartaglia, E. Zaccarelli, and F. Sciortino, Phase Diagram of Patchy Colloids: Towards Empty Liquids, Phys. Rev. Lett. **97**, 168301 (2006).
[5] A. Reinhardt and D. Frenkel, Numerical Evidence for Nucleated Self-Assembly of DNA Brick Structures, Phys. Rev. Lett. **112**, 238103 (2014).
[6] H. M. Jaeger, S. R. Nagel, and R. P. Behringer, Granular solids, liquids, and gases, Rev. Mod. Phys. **68**, 1259 (1996).
[7] C. Coulais, A. Segiun, and O. Dauchot, Shear Modulus and Dilatancy in Granular Packings above Jamming, Phys. Rev. Lett. **113**, 198001 (2014).
[8] M. A. Dias, L. H. Dudte, L. Mahadevan, and C. D. Santangelo, Geometric Mechanics of Curved Crease Origami, Phys. Rev. Lett. **109**, 114301 (2012).
[9] C. Py, P. Reverdy, L. Doppler, J. Bico, B. Roman, and C. Baroud, Capillary Origami: Spontaneous Wrapping of a Droplet with an Elastic Sheet, Phys. Rev. Lett. **98**, 156103 (2007).
[10] G. S. Redner, M. F. Hagan, and A. Baskaran, Structure and Dynamics of a Phase-Separating Active Colloidal Fluid, Phys. Rev. Lett. **110**, 055701, 2013.
[11] J. Palacci, S. Sacanna, A. P. Steinberg, D. J. Pine, and P. M. Chaikin, Living crystals of light activated colloidal surfers, Science **339**, 936 (2013).
[12] J. A. Cohen and R. Golestanian, Emergent Cometlike Swarming of Optically Driven Thermally Active Colloids, Phys. Rev. Lett. **112**, 068302 (2014).
[13] T. C. Lubensky, D. Pettey, and N. Currier, Topological defects and interactions in nematic emulsions, Phys. Rev. E **57**, 610 (1998).
[14] R. D. Kamien, The geometry of soft materials: A primer, Rev. Mod. Phys. **74**, 953 (2002).
[15] T. Vicsek, A. Czirók, E. Ben-Jacob, I. Cohen, and O. Shochet, Novel Type of Phase Transition in a System of Self-Driven Particles, Phys. Rev. Lett. **75**, 1226 (1995).
[16] I. D. Vladescu, E. J. Marsden, J. Schwarz-Linek, V. A. Martinez, J. Arlt, A. N. Morozov, D. Marenduzzo, M. E. Cates, and W. C. K. Poon, Filling an Emulsion Drop with Motile Bacteria, Phys. Rev. Lett. **113**, 268101 (2014).
[17] M. C. Marchetti, J. F. Joanny, S. Ramaswamy, T. B. Liverpool, J. Prost, M. Rao, and R. Aditi Simha, Hydrodynamics of soft active matter, Rev. Mod. Phys. **85**, 1143 (2013).
[18] http://www.aps.org/units/gsoft/.
[19] S. Mora, T. Phou, J.-M. Fromental, and Y. Pomeau, Gravity Driven Instability in Elastic Solid Layers, Phys. Rev. Lett. **113**, 178301 (2014).
[20] M. Backholm, R. D. Schulman, W. S. Ryu, and K. Dalnoki-Veress, Tangling of Tethered Swimmers: Interactions between Two Nematodes, Phys. Rev. Lett. **113**, 138101 (2014).
[21] N. H. P. Nguyen, D. Klotsa, M. Engel, and S. C. Glotzer, Emergent Collective Phenomenon in a Mixture of Hard Shapes through Active Rotation, Phys. Rev. Lett. **112**, 075701 (2014).
[22] S. S. Datta, S.-H. Kim, J. Paulose, A. Abbaspourrad, D. R. Nelson, and D. A. Weitz, Delayed Buckling and Guided Folding of Inhomogeneous Capsules, Phys. Rev. Lett. **109**, 134302 (2012).