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Universality in Nonlinear Elasticity of Biological and Polymeric Networks and Gels[1] JAN-MICHAEL CARRILLO, ANDREY DOBRYNIN, Department of Physics, University of Connecticut — Networks and gels are part of our everyday experience starting from automotive tires and rubber bands to biological tissues and cells. Biological and polymeric networks show remarkably high deformability at relatively small stresses and can sustain reversible deformations up to ten times of their initial size. A distinctive feature of these materials is highly nonlinear stress-strain curves leading to material hardening with increasing deformation. This differentiates networks and gels from conventional materials, such as metals and glasses, showing linear stress-strain relationship in the reversible deformation regime. Using theoretical analysis and molecular dynamics simulations we propose and test a model that describes nonlinear mechanical properties of a broad variety of biological and polymeric networks and gels by relating their macroscopic strain hardening behavior with molecular parameters of the network strands. This model provides a universal relationship between the strain-dependent network modulus and the network deformation and explains strain-hardening of natural rubber, synthetic polymeric networks, and biopolymer networks of actin, collagen, fibrin, vimentin and neurofilaments.

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