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Foreword

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One of the goals of the *Journal of Elasticity: The Physical and Mathematical Science of Solids* is to identify and to bring to the attention of the physical and mathematical sciences research community masterful expositions which contain creative ideas, new approaches and current developments in modeling the behavior of materials. The phenomenon of fracture has enjoyed the attention of fundamental and applied researchers for many years. Its influence on, and responsibility in part for, major growth in fundamental aspects of solid mechanics from the physical modeling of the phenomenon itself, to the development of mathematical techniques for handling singularities, to the establishment of computational methods at large and small scales, and to the development of novel experimental strategies and techniques, is well-known. In relatively recent years, a common theoretical basis and unification has begun to emerge in the fields of fracture, plasticity and damage; a focus on the phenomenon of stability has driven this emergence. The work presented here shows several fundamental and important advances toward this aim, and it presents proposals on how this may be accomplished.

This invited article by Gianpietro Del Piero develops in a masterful way the subject of quasi-static brittle and diffuse fracture from a unified variational point of view based on 'incremental energy minimization'. The article begins with the classical theory of brittle facture due to Griffith. The theory is then regularized so as to include dissipation and elastic unloading via the introduction of surfacial cohesive energies due to Barenblatt and Dugdale. An intriguing description of the formation of microstructure is given and the concept of irreversibility is examined. A diffusive 'process zone' then is introduced into the theory. This generalization recognizes that the fracture energy accompanied with crack growth is not always surfacial in nature, but also can include the particles of the body away from the crack. The assumed existence of a process zone establishes a strong connection with the theories of plasticity and damage. With this, it is then made evident that the incompatibility between the classical theory of plasticity based on Drucker's postulate and the phenomenon

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of strain softening can be completely resolved with the introduction of a non-local cohesive energy term of the gradient type.

The presentation is comprehensive, written in the style of a series of lectures, one building upon the next. The article includes a large bibliography; at the end of each lecture helpful comments and pertinent references and interpretations regarding modern developments are offered. In order to enlarge the unified theory to the greatest extent and to avoid complex mathematical analysis, the treatment is restricted to one-dimension. The main message is that fracture, plasticity, damage and the creation of microstructure have common theoretical bases, and that they can be treated in a unified way using 'incremental energy minimization' as a basic analytical tool. The non-trivial challenge for the future is to consider this possibility in a two or three dimensional setting.