Gels, Cells, and the Engines of Motion

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ABSTRACT

This talk is a modest tribute to the inspiring book by Pollack [1], where the author puts forward the hypothesis that cells are not aqueous solutions, as mainstream biochemistry has tended to assume; rather, the cytoplasm is there described as a complex gel, and much of the behavior of cells is explained by gel-specific concepts such as anisotropic phase transitions and selective diffusion of specific solutes from the gel matrix.

Our involvement dates back to the seminal paper [2] that prompted us a thoroughly study of non linear elasticity with large, evolving distortions (dubbed relaxed stances in the original paper); we realized that, in spite of the huge amount of literature dealing with thermal strains–usually small and isotropic, few scholars tackled problems having large, non isotropic distortions, evolving in time.

At first, we proposed the use of the notion of large distortions as a modeling tool for soft material [3]; since then, the same tool proved very useful in modeling apparently disparates phenomena such as muscle contractions, [4, 5], director reorientations in nematic elastomers [6], phase transitions in nematic gels, [7], actuation of Ionic Polymer Metal Composites [8]. A distinctive attribute for all these phenomena is that large displacements are triggered by evolving distortions; two more papers that is worth citing are [9], containing brilliant experimental results, and [10], an Editorial for a monographic issue of Soft Matter.

Only recently, we began investigating about compatibility issues: to what extent does a given distortion field (a tensor valued field) represent the metric of a global configuration in the Euclidean space? Or, to put it simpler, can a distortion field be realizable?

This question has important consequences: if the answer is positive, then it is possible to realize, through distortions, very large shape changes at no, or low, change of the elastic energy [11]. Thus, the characterization of realizable distortions should be helpful in giving new insight into the *mechanisms* underlying motion of soft matter, or in the designing of artificial actuators.

In this talk we shall try to put together many puzzling pieces of evidence, in order to address the challenge of modeling responsive and active materials that undergo large motions in response to a wide range of stimuli.

References

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