

A CONTINUUM FRAMEWORK FOR GROWTH IN BIOLOGICAL TISSUE: THE ROLES OF MASS TRANSPORT AND MECHANICS

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ABSTRACT A framework for the macroscopic treatment of growth in biological tissue is formulated within the context of open-system thermodynamics. Some classical continuum mechanics assumptions are found to be too restrictive for the growth of a body, and these are revised for the present treatment. In particular, sources and fluxes of species, and the concomitant momentum and energy transfer among them, enhance the classical balance laws. A central result of this formulation, which has been absent in previous attempts for this problem, is that the full extent of coupling between mass transport and mechanics emerges directly from the thermodynamics. The present work examines the role of this coupling in ensuring consistent rendering of the physics.

The principal assumption that departs from the rubrics of classical continuum mechanics is that the system of interest is open with respect to mass. Scalar mass sources and sinks and vectorial mass fluxes are to be considered in growth. The diffusing species is not the tissue itself. Rather, there are various tissue precursor species or by-products of tissue formation that diffuse through the tissue. At the very least in biological tissue there exist a solid and a fluid phase and the continuum aspects of tissue growth must be treated in the context of mixture theory. When growth is occurring there are additional diffusing species as described above. In the present formulation, the dissipation inequality is used to motivate a constitutive law for the mass flux of each diffusing species.

