A CONTINUUM TREATMENT OF GROWTH IN SOFT BIOLOGICAL TISSUE: COUPLING OF MASS TRANSPORT AND MECHANICS

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Growth (and resorption) of biological tissue is formulated in the continuum setting. The treatment is macroscopic, rather than cellular or sub-cellular. Certain assumptions that are central to classical continuum mechanics are revisited, the theory is reformulated, and consequences for balance laws and constitutive relations are deduced. Sources and fluxes of mass, and terms for momentum and energy transfer between species are introduced to enhance the classical balance laws. The transported species include: (i) precursors and byproducts of reactions that create tissue and break it down, and (ii) a fluid phase. A notable feature is that the full extent of coupling between mass transport and mechanics emerges from the thermodynamics. A systematic and simultaneous derivation of both effects appears to have been overlooked heretofore for this problem. In particular, Fickean and stress-mediated mass transport have not emerged naturally from previous formulations of the problem. The present work demonstrates both these effects via a physically-consistent treatment. Furthermore, it takes account of the multiple, interacting species that are present. This fact requires the framework of mixture theory, and has far-reaching ramifications. Computations will be presented for several scenarios of growth in soft biological tissue that demonstrate the influence of this coupling.