Growth is a distinguishing feature of all living things. Unlike standard materials, living materials respond autonomously to environmental changes. As a result of a continuous turnover and renewal of cells and extracellular matrix, living systems can undergo extreme changes in composition, size, and shape. However, the precise role of mechanics throughout these processes remains largely unknown. Here Dr. Kuhl uses the nonlinear field theories of mechanics supplemented by the theory of finite growth to explore the extreme mechanics of growing matter. Examples are plentiful ranging from plants to tumors, from the lungs to the vasculature, and from skeletal to cardiac muscle. Dr. Kuhl will discuss the role of mechanics in important clinical applications like asthma, chronic bronchitis, atherosclerosis, restenosis, tissue expansion, limb lengthening, mitral regurgitation, cardiomyopathy, heart failure, and brain development. Understanding the mechanisms of growth in these chronic conditions may open new avenues in medical device design and personalized medicine to manipulate development and alter, control, or revert disease progression.

Ellen’s professional expertise is living matter physics, the creation of theoretical and computational models to predict the acute and chronic response of living structures to environmental changes during development and disease. Her specific interest is the multiscale modeling of growth and remodeling, the study of how living matter adapts its form and function to changes in mechanical loading, and how this adaptation can be traced back to structural alterations on the cellular or molecular levels. Growth and remodeling can be induced naturally, e.g., through elevated pressure, stress, or strain, or interventionally, e.g., through prostheses, stents, tissue grafts, or stem cell injection. Combining theories of electrophysiology, photoelectrochemistry, biophysics, and continuum mechanics, Ellen’s lab has specialized in predicting the chronic loss of form and function in growing and remodeling cardiac tissue using patient-specific custom-designed finite element models.

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