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Extreme Mechanics of Growing Matter[1]

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Growth is a distinguishing feature of all living things. Unlike standard materials, living matter can autonomously respond to alterations in its environment. As a result of a continuous ultrastructural turnover and renewal of cells and extracellular matrix, living matter can undergo extreme changes in composition, size, and shape within the order of months, weeks, or days. While hard matter typically adapts by increasing its density to grow strong, soft matter adapts by increasing its volume to grow large. Here we provide a state-of-the-art review of growing matter, and compare existing mathematical models for growth and remodeling of living systems. Applications are plentiful ranging from plant growth to tumor growth, from asthma in the lungs to restenosis in the vasculature, from plastic to reconstructive surgery, and from skeletal muscle adaptation to heart failure. Using these examples, we discuss current challenges and potential future directions. We hope to initiate critical discussions around the biophysical modeling of growing matter as a powerful tool to better understand biological systems in health and disease.

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