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Bioinspired Composite Design for Enhanced Mechanics: Part 2 -Dr. Zhao Qin, University of Syracure

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Natural materials exhibit remarkable functions—self-growth, mechanical strength, energy efficiency, environmental friendliness, and tunability—achieved through multiscale structures. Unlocking their gene-structure-function relationships and innovatively applying these materials is essential for transitioning from petroleum-based development to a sustainable, circular future. Through multiscale material modeling and collaborations, we integrate AI-driven modeling, 3D printing with advanced in situ synchrotron-based characterization techniques to study bioinspired composites and optimize their design. For example, we recently examined bamboo epidermis, where the disorder dispersion of silica particles enhances strength by mitigating defects and arresting crack propagation. By combining AI-guided analysis with 3D printing, we revealed how mesoscopic silica distributions significantly improve mechanical strength in fracture. Additionally, we explored mycelium fibers, which grow and bind within porous media such as wood and fibrous networks. Acting as a sacrificial layer, mycelium enhances material toughness and mitigates failure. Through AI-enabled insights and synchrotron-based characterization, we unraveled the mechanisms underpinning these enhancements, paving the way for sustainable applications. Our work spans from molecular modeling to large-scale building and energy applications, offering sustainable, strong, tough, and thermally stable materials for a wide array of challenges.