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Designing Jammed Materials from the Particle Up

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Identifying which microscopic features produce a desired macroscopic behavior is a problem at the forefront of materials science. This task is materials design, and within it, new challenges have emerged from tailoring packings of particles jammed into a rigid state. For these materials, particle shape is a key parameter by which the response of a packing can be tuned. Yet designing via shape faces two unique complications: first there is no general theory that calculates the response of an aggregate given a particle shape, and second, there is no straightforward way to explore the space of all particle geometries. This talk summarizes recent results that address these challenges to design jammed materials from the particle up. It shows how simulations, experiments, and state-of-the-art optimization engines come together to form a complete system that identifies extreme materials. As examples, it will show how this system can create particle shapes that form the stiffest, softest, densest, loosest, most dissipative and strain-stiffening aggregates. Finally, it will discuss the how these results relate to the general task of materials design and the exciting possibilities associated with optimizing, tuning and rationally constructing new breeds of jammed materials.