Cross-Dimensional Technology: From Waste to Novel Materials

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Throughout history, new materials have been the foundation of disruptive technologies1: From bronze, paper, and ceramics to steel, polymers, and semi-conductors, each material enabled far-reaching advances and defined the era. Seventy years ago, the synthesis of pure semiconductors as single crystals led to a complete transformation of the electronics industry leading to sweeping changes in communications, computing, and transportation2. Today, inspired by the United Nation's Sustainable Development Goals (SDGs) – which seek to provide a blueprint for achieving a better and more sustainable future for all3 – entirely new classes of materials are being envisioned. These new materials will have the potential to alleviate environmental burden, provide radically new functions, and to fundamentally challenge our notion of what constitutes a "material." Among them, multicomponent multifunctional materials, inspired and co-opted from biology, are particularly attractive. These materials feature (1) hybrid-composite design, combining disparate building blocks; (2) compartmentalized architecture, encapsulating desirable biomolecules while excluding others; and (3) hierarchical organization4. Together, they enable unusual combinations of properties, including adaptability, plasticity, multi-functionality, and environmental responsiveness – far beyond those achieved by monolithic materials of the synthetic world.

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