This paper presents a design and fabrication of solution-processed scalable 3D/2D heterostructures for highly efficient and durable conversion of light to electrical energy. Realizing solution-processed heterostructures is a challenge in halide perovskites because of solvent incompatibilities that disrupt the underlying layer. By leveraging the solvent dielectric constant and Gutmann donor number, we grow tunable phase-pure 2D halide perovskite bilayer stacks of the desired composition, thickness, and bandgap onto 3D perovskites without dissolving the underlying substrate. Characterization reveals a 3D-2D transition region of 20 nm, mainly determined by the roughness of the bottom 3D layer. Thickness dependence of the 2D perovskite layer reveals the anticipated trends for n-i-p and p-i-n architectures, consistent with band alignment and carrier transport limits for 2D perovskites. We measure a PV efficiency of 24.5%, with exceptional stability of T99>2000 hours, implying that the 3D/2D bilayer inherits the intrinsic durability of 2D perovskite without compromising efficiency.