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Photosynthesis Revisited: Optimization of Charge and Energy Transfer in Quantum Materials NATHANIEL GABOR, Department of Physics and Astronomy, University of California Riverside — The integration of new nano- and molecular-scale quantum materials into ultra-efficient energy harvesting devices presents significant scientific challenges. Of the many challenges, the most difficult is achieving high photon-to-electron conversion efficiency while maintaining broadband absorption. Due to exciton effects, devices composed of quantum materials may allow near-unity optical absorption efficiency yet require the choice of precisely one fundamental energy (HOMO-LUMO gap). To maximize absorption, the simplest device would absorb at the peak of the solar spectrum, which spans the visible wavelengths. If the peak of the solar spectrum spans the visible wavelengths, then why are terrestrial plants green? Here, I discuss a physical model of photosynthetic absorption and photoprotection in which the cell utilizes active feedback to optimize charge and energy transfer, thus maximizing stored energy rather than absorption. This model, which addresses the question of terrestrial greenness, is supported by several recent results that have begun to unravel the details of photoprotection in higher plants. More importantly, this model indicates a novel route for the design of next-generation energy harvesting systems based on nano- and molecular-scale quantum materials.

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