Five Ways Scientists Want to Hack Plants to Improve Photosynthesis

The amount of land dedicated to farming is shrinking, the world’s crop productivity is stagnating, and the population is still growing. What are we going to do about the looming agricultural crisis? An international team of 25 researchers just published a piece in the journal for the Proceedings for the National Academy of Sciences that suggests it’s time photosynthesis was upgraded.

According to the authors, we need agricultural productivity to rise by 60 to 120 percent over 2005 levels to meet growing demand for food and other agricultural products like biofuel, yet they say replicating the growth in agricultural yields seen last century is going to take a novel approach.

“The remarkable gains in productivity of the Green Revolution of the late 20th century depended on improving yield potential: i.e., the yield obtained with good nutrition in the absence of pests, diseases, and drought,” the paper states. While the availability of water is still a major limiting factor, “there are few options for dramatically reducing the amount of water required to grow a crop.”

But the researchers see a lot of potential ways, taking from nature's own toolbox, to make photosynthesis more efficient.

Their list of places and means with which to start:

1. Improve the efficiency with which plants capture light. It turns out plants can actually capture too many photons, and safely extinguishing this excess energy makes them less efficient. So if science can reduce the amount of chlorophyll and carotenoids in plants, light could be absorbed “more judiciously.”

2. Improve the efficiency by which plants turn light into energy. Here, the researchers want to engineer a more efficient photosynthetic pathway to maximize the usage of every potential photon. They propose taking a page from purple photosynthetic bacteria in order to fine-tune the photosynthetic process to "achieve a near-optimum match of the solar spectrum to water oxidation and carbohydrate/lipid synthesis."

3. Improve carbon uptake. This one is actually intimately related to a desire to use less water. The less time that a plant’s stomata are open, exchanging gases, the less water plants require.
4. **Improve carbon use.** This one is already being worked on—an effort to make rice conduct photorespiration more like sugarcane and corn has already yielded “exciting results,” according to the paper. Another approach is reengineering plants to be more like cyanobacteria, which use enzyme-containing compartments called carboxysomes to efficiently concentrate carbon dioxide.

Engineering plants to grow lighter leaves that block out less light on top and dark, more light-collecting plants at their base would increase efficiency of the plant as a whole. Image: PNAS

5. **Smart canopy.** This one is the most straight-forward sounding: "The smart canopy concept envisions an assemblage of plants that interact cooperatively (rather than competitively) at the canopy level to maximize the potential for light harvesting and biomass production per unit land area," the author writes. In other words, they want to engineering plants and develop crop planting schemes that increase the penetration of sunlight into lower-level leaves.
Of course, reworking photosynthesis is going to “call for the introduction of dozens of transgenes—possibly on synthetic chromosomes—and require genetic engineering at an unprecedented scale, as well as public discussion of the costs and benefits of such organisms.” According to the paper, we’re far more ready for the former than the latter. We’ve got 30 years of research on transgenes, and many inspirations in nature to draw from. As for the ability to a rational discussion about genetically modified organisms… well.