Reconfiguring Plant Metabolism for Biodegradable Plastic Production

U.S. DEPARTMENT OF ENERGY | Office of Science

Background

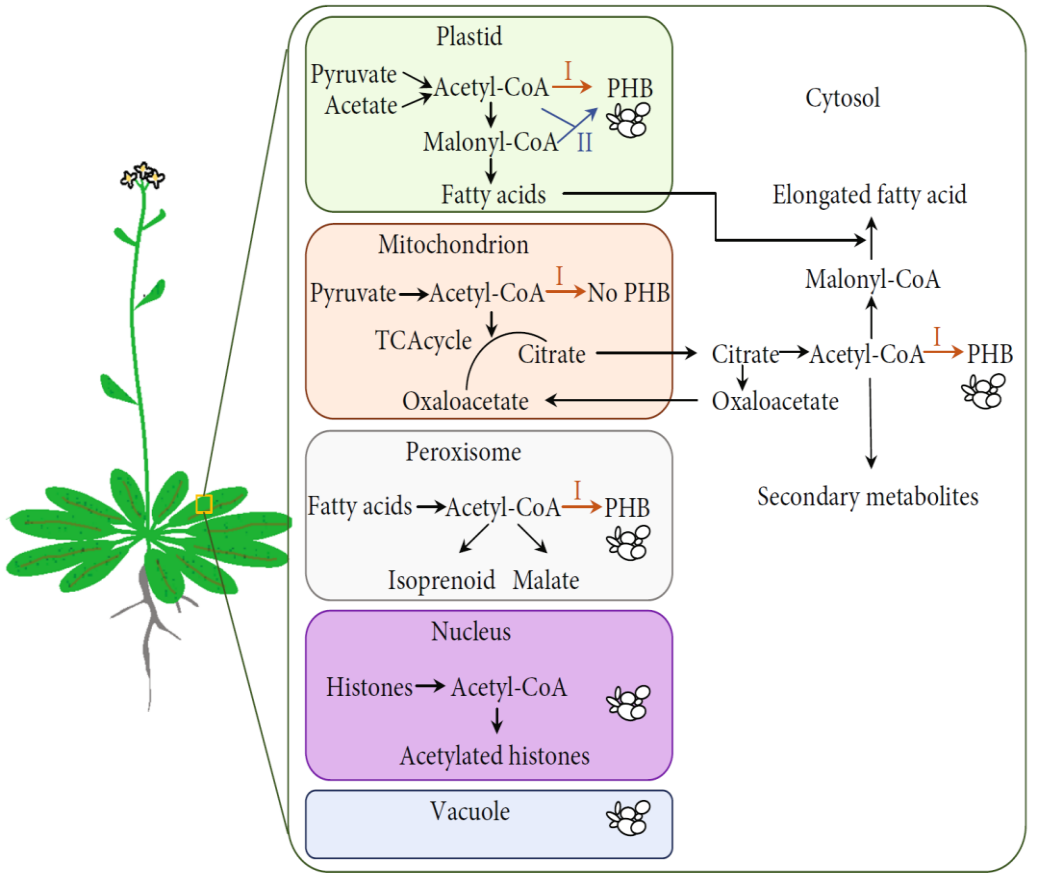
- Polyhydroxyalkanoates (PHAs), a large class of biopolymers naturally synthesized in eubacteria, can be used for producing biodegradable plastics. However, after three decades of effort synthesizing PHAs in plants, it remains difficult to reach commercial production due to the growth defects associated with PHA production and accumulation in plant cells.

Conclusions

- Optimization of plant-based PHA production requires consideration of the timing and duration of organelle-targeted PHA biosynthesis, relocation, and storage.
- Molecular dynamic simulations suggest temporal control of PHA biosynthesis could be achieved through the use of inducible or native developmental stage-specific promoters.
- Genetic circuits need to be designed for maximizing PHA biosynthesis and storage capability of plastids and other targeted organelles, as well as facilitating the relocation and secretion of the PHA polymers.

Significance

- This article provides new insights into the application of systems and synthetic biology approach to the reconfiguration of plant metabolism for high levels of PHA production, with minimal detrimental impacts on plant growth.
- Our strategy for optimizing plant-based PHA production has a great potential to increase the bioeconomy value of bioenergy crops and help solve the challenge caused by plastic pollution.



A summary of plant organelles that have been found to produce and/or accumulate PHB granules. Black arrows indicate endogenous acetyl-CoA metabolic pathways; orange and blue arrows indicate engineered PHB biosynthesis pathways using genes encoding enzymes in pathways I and II, respectively. Granules indicate the accumulation of PHB granules.

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