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Photosynthesis results in ^{2}H-depleted carbohydrates, but why?

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When you grow plants in the light, the hydrogen isotopic composition (δ^{2}H) of plant compounds such as cellulose show lower δ^{2}H values (are ^{2}H-depleted) relative to plants grown heterotrophically in the dark. Therefore, it is logical to assume that photosynthetic reactions introduce ^{2}H-depleted hydrogen atoms into carbohydrates. But where in the C reductive pathway (Calvin-Benson-Bassham cycle, CBB) does this occur? Or more interestingly, can we interpret the degree of ^{2}H-depletion of plant compounds with respect to this key reaction(s)? With the recent resurgence of studies offering hydrogen isotopes as a new proxy for plant central carbon and energy metabolism, such a fundamental question seems pertinent to answer.

We 1) examine the stereospecific mechanism of hydride transfer via NADP(H) catalyzed by oxidoreductases (ferredoxin-NADP^{+} reductase, glyceraldehyde 3-phosphate dehydrogenase) as a key reason why photoproduced NADPH is not directly the source of ^{2}H-depletion of autotrophically produced carbohydrates, 2) reconcile the site-specific deuterium abundance pattern differences between C_3 and C_4 (NADP-ME) species of hydrogen bound to position C-4 in glucose, and 3) urge greater investment in position-specific and complimentary metabolomic analyses to progress the development of hydrogen isotopes as a metabolic proxy.