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research highlights

STARCH SYNTHESIS

Seeding the pearl

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Starch is the main form of energy storage in plants; most of the calories that humanity consumes come directly or indirectly from harvested plant starch in the form of fruits, grains or tubers. This polymer of glucose also accumulates in chloroplasts during the day, as insoluble granules, and is degraded during the night when the sun is not available. These granules have a complex concentric structure, and their number is strictly controlled under genetic regulation — about 5–7 granules per chloroplast in *Arabidopsis*. Despite how widespread starch granules are, the mechanism of their initiation is not known. Sam Zeeman and colleagues now identify two proteins involved in this important biological process.

The researchers first found two genes of unknown function that have a partially similar structure, including a carbohydrate binding domain, with a gene named *PROTEIN TARGETING TO STARCH 1* (*PTST1*) that is important for the correct synthesis of amylose, the non-branched

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component of starch. They named these *PTST2* and *PTST3*. The encoded proteins co-localize inside chloroplasts and are partially redundant in function. Single and double mutants have a similar amount and quality of starch overall, although they synthetize and degrade it more slowly than the wild type. These mutants have dramatically fewer, but larger, granules per chloroplast, suggesting a role restricted to granule initiation. Conversely, overexpressor plants have more and smaller granules. PTST2 interacts with, and depends for its functioning on, starch synthase enzyme SS4, a protein already known to be involved in granule initiation. PTST2 also interacts with glucose oligomers but only when they are long enough to form a helical structure.

This series of experiments using cell biology, biochemistry and genetics strongly suggests that PTST2/3 proteins are part of a complex that is able to initiate starch granules. They may do that first by binding to oligomers of glucose, and then by recruiting SS4 to elongate the chain. A low abundance of these oligomers in the chloroplast, combined with tightly controlled levels of PTST priming proteins, SS4 and others yet to be discovered, may be the key that restricts granule initiation to such low numbers.

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