Researchers uncover structure of enzyme that makes plant cellulose

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Purdue researchers have discovered the structure of the enzyme that makes cellulose, a finding that could lead to easier ways of breaking down plant materials to make biofuels and other products and materials.

The research also provides the most detailed glimpse to date of the complicated process by which cellulose - the foundation of the plant cell wall and the most abundant organic compound on the planet - is produced.

"Despite the abundance of cellulose, the nitty-gritty of how it is made is still a mystery," said Nicholas Carpita, professor of plant biology. "Now we're getting down to the molecular structure of the individual enzyme proteins that synthesize cellulose."

Cellulose is composed of several dozen strands of glucose sugars linked together in a cablelike structure and condensed into a crystal. The rigidity of cellulose allows plants to stand upright and lends wood its strength.

"Pound for pound, cellulose is stronger than steel," Carpita said.

A large protein complex synthesizes cellulose at the surface of the plant cell. The basic unit of this complex is an enzyme known as cellulose synthase. The protein complex contains up to 36 of these enzymes, each of which has a region known as the catalytic domain, the site where single sugars are added to an ever-lengthening strand of glucose that will be fixed in the plant cell wall as one of the strands in the cellulose "cable."

Carpita and a team of researchers used X-ray scattering to show that cellulose synthase is an elongated molecule with two regions - the catalytic domain and a smaller region that couples with another cellulose synthase enzyme to form a dimer, two molecules that are stuck together. These dimers are the fundamental building blocks of the much larger protein complex that produces cellulose.

"Determining the shape of cellulose synthase and how it fits together into the protein complex represents a significant advance in understanding how these plant enzymes work," Carpita said.

The findings could be used to redesign the structure of cellulose for different material applications, he said. For example, cellulose - the base for many textiles such as cotton and rayon - could be modified to better absorb dyes without chemical treatments. The structure of cellulose could also be altered to break down more easily for the production of cellulosic biofuels.

"For decades, we've been doing our best to replace cellulose and other natural products with compounds made from oil," Carpita said. "Plant biologists are now beginning to do the reverse - combining new knowledge from genetics, genomics and biochemistry to make new kinds of natural products to replace those we now make from oil."

More information: "The structure of the catalytic domain of a plant cellulose synthase and its assembly into dimers"—the paper was published in The *Plant Cell* and is available at www.plantcell.org/content/26/7/2996.full