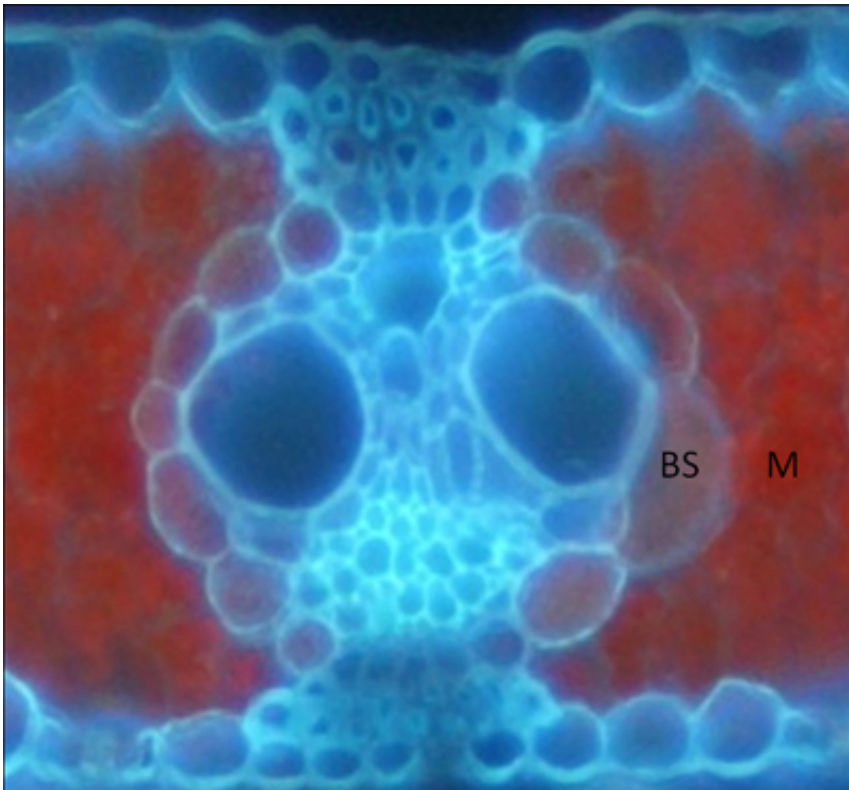


# Scientists discover genetic key to efficient crops

January 24 2013, by Krishna Ramanujan

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Cross section of a mature maize leaf showing Kranz (German for wreath) anatomy around a large vein. The bundle sheath cells (lighter red) encircle the vascular core (light blue). Mesophyll cells (dark red) encircle the bundle sheath cells. The interaction and cooperation between the mesophyll and bundle sheath is essential for the C4 photosynthetic mechanism. Credit: Thomas Slewinski

(Phys.org)—With projections of 9.5 billion people by 2050, humankind

faces the challenge of feeding modern diets to additional mouths while using the same amounts of water, fertilizer and arable land as today.

Cornell researchers have taken a leap toward meeting those needs by discovering a gene that could lead to new varieties of [staple crops](#) with 50 percent higher yields.

The gene, called Scarecrow, is the first discovered to control a special leaf structure, known as Kranz anatomy, which leads to more efficient [photosynthesis](#). Plants photosynthesize using one of two methods: C3, a less efficient, ancient method found in most plants, including wheat and rice; and C4, a more efficient adaptation employed by grasses, maize, [sorghum](#) and [sugarcane](#) that is better suited to drought, intense sunlight, heat and low nitrogen.

"Researchers have been trying to find the underlying genetics of Kranz anatomy so we can engineer it into C3 crops," said Thomas Slewinski, lead author of a paper that appeared online in November in the journal *Plant and Cell Physiology*. Slewinski is a postdoctoral researcher in the lab of senior author Robert Turgeon, professor of [plant biology](#).

The finding "provides a clue as to how this whole anatomical key is regulated," said Turgeon. "There's still a lot to be learned, but now the barn door is open and you are going to see people working on this Scarecrow pathway." The promise of transferring C4 mechanisms into C3 plants has been fervently pursued and funded on a global scale for decades, he added.

If C4 photosynthesis is successfully transferred to C3 plants through [genetic engineering](#), farmers could grow wheat and rice in hotter, dryer environments with less fertilizer, while possibly increasing yields by half, the researchers said.

C3 photosynthesis originated at a time in Earth's history when the atmosphere had a high proportion of carbon dioxide. [C4 plants](#) have independently evolved from C3 plants some 60 times at different times and places. The C4 adaptation involves Kranz anatomy in the leaves, which includes a layer of special bundle sheath cells surrounding the veins and an outer layer of cells called mesophyll. Bundle sheath cells and mesophyll cells cooperate in a two-step version of photosynthesis, using different kinds of chloroplasts.

By looking closely at plant evolution and anatomy, Slewinski recognized that the bundle sheath cells in leaves of C4 plants were similar to endodermal cells that surrounded vascular tissue in roots and stems.

Slewinski suspected that if C4 leaves shared endodermal genes with roots and stems, the genetics that controlled those cell types may also be shared. Slewinski looked for experimental maize lines with mutant Scarecrow genes, which he knew governed endodermal cells in roots. When the researchers grew those plants, they first identified problems in the roots, then checked for abnormalities in the bundle sheath. They found that the leaves of Scarecrow mutants had abnormal and proliferated bundle sheath cells and irregular veins.

In all plants, an enzyme called RuBisCo facilitates a reaction that captures carbon dioxide from the air, the first step in producing sucrose, the energy-rich product of photosynthesis that powers the plant. But in C3 plants RuBisCo also facilitates a competing reaction with oxygen, creating a byproduct that has to be degraded, at a cost of about 30-40 percent overall efficiency. In C4 [plants](#), carbon dioxide fixation takes place in two stages. The first step occurs in the mesophyll, and the product of this reaction is shuttled to the bundle sheath for the RuBisCo step. The RuBisCo step is very efficient because in the bundle sheath cells, the oxygen concentration is low and the [carbon dioxide](#) concentration is high. This eliminates the problem of the competing

oxygen reaction, making the plant far more efficient.

Provided by Cornell University

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