

By Steve Werblow

RIGHT BEFORE YOUR EYES

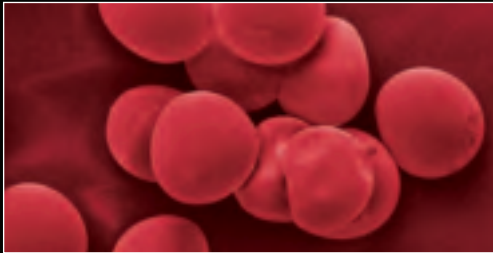


PHOTO: DEBRA SHERMAN, PURDUE

*An everyday corn field
is a vibrant ecosystem*

Look closely at that corn field. It's easy to see a familiar sight—30,000 or so plants per acre swaying in a summertime breeze, high as an elephant's eye. But walk into the field and take a closer look. Look close enough to see the pollen drifting in the rough midrib of a yard-long leaf, piled up like tumbleweeds in a ditch. Close enough to spot the ladybeetle larva prowling the leaf's collar, hunting for lunch. Close enough to recognize that your everyday corn field is a bustling jungle and a towering human accomplishment.

Ancient crop. Most crops at least somewhat resemble their wild forebears, but corn is tamer than a lap dog. As long as 9,000 years ago, man trapped corn's kernels in tightly wrapped ears, leaving the crop almost completely dependent upon people to spread its seed. ♪

▶**Large photo:** Each silk in an ear of corn directs pollen to a single ovule. A developing ear starts with as many as 1,000 potential kernels. ▶**Inset photo:** Corn pollen grains collect on a leaf in this scanning electron microscope photograph. Pollen can travel extensively on the wind, but most corn pollen grains land just a few feet from their starting point.

Corn's most likely ancestor, teosinte, still dots the highlands of Mexico and Central America with its sprawling mass of stalks and tiny columns of hard, trapezoidal kernels. You can see the family resemblance—teosinte's little ears sprout fuzzy silks, and pollen-bearing tassels festoon the tops of its stalks. But debates rage about how future farmers of the Americas helped make the jump from shatter-prone teosinte to sturdy-eared corn.

Missing link. Mary Eubanks, a cross-trained anthropologist/biologist, kicked up a storm in genetics circles by declaring that there could be a missing link, a cross with gamagrass. In the 1980s, Eubanks successfully crossed teosinte and gamagrass, writing a new page to one of agriculture's great mysteries.

Today's corn field is an extraordinary powerplant. It becomes a massive factory that turns inputs of water, light, and carbon dioxide into grain and more than 5 tons of root and shoot dry mass per acre.

Converting solar energy into chemical energy—stored as sugars and starches—is “the most wondrous trick that plants can do,” says

Corn produces about 1/3 of a mile of roots per plant, about as much mass below the ground as above.



► **Large photo:** The three-stamen flowers of the corn tassel produce up to 5 million grains of pollen per plant. ► **Right:** Corn fields provide home or stopover for an array of arthropods, including this muscid fly.



University of Illinois agronomist Emerson Nafziger. We can stand in the sun and not derive a calorie of nutrition from the experience, but a corn plant can turn a sunny day into 7.5 grams of sugar—and make 10 bushels of grain per acre from that day's worth of solar energy.

Nafziger describes photosynthesis as “the reverse of burning.” Plants use energy and carbon dioxide to make sugar and oxygen. After a bowl of Corn Flakes, our cells combine the sugars we ate with oxygen to release energy and CO₂.

Water is also vital. On a hot, windy, sunny summer day, an acre of corn can consume a quarter-inch or more of water, or about a quart per plant. By the end of the season, each plant in a 200-bushel crop will use about 20 gallons.

Underground world. A fully grown corn plant draws its water through as much as one-third of a mile of roots, notes Nafziger.

But no matter how many miles of roots snake through the soil, all transactions take place one cell at a time. Water and nutrients squeeze into the plant through specialized root hair cells. Inside the root, endodermal cells—each ringed by a waterproof gasket called a

A teaspoonful of healthy soil contains up to 100 million bacterial cells, and 1 million protozoa.

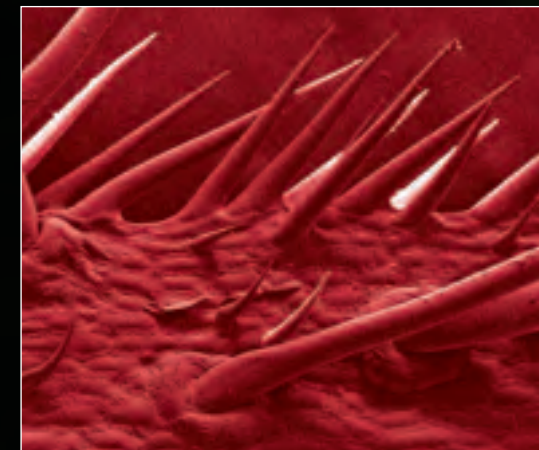


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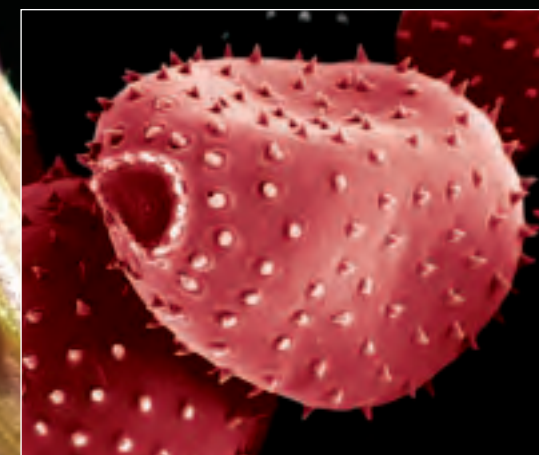


PHOTO: RAY SCHNEIDER, LSU

► **Upper left:** Leaf hairs help reduce water loss by interfering with the flow of air over the leaf. ► **Left:** Pollen shares the wind with disease propagules like these fearsome Southern corn leaf rust spores.

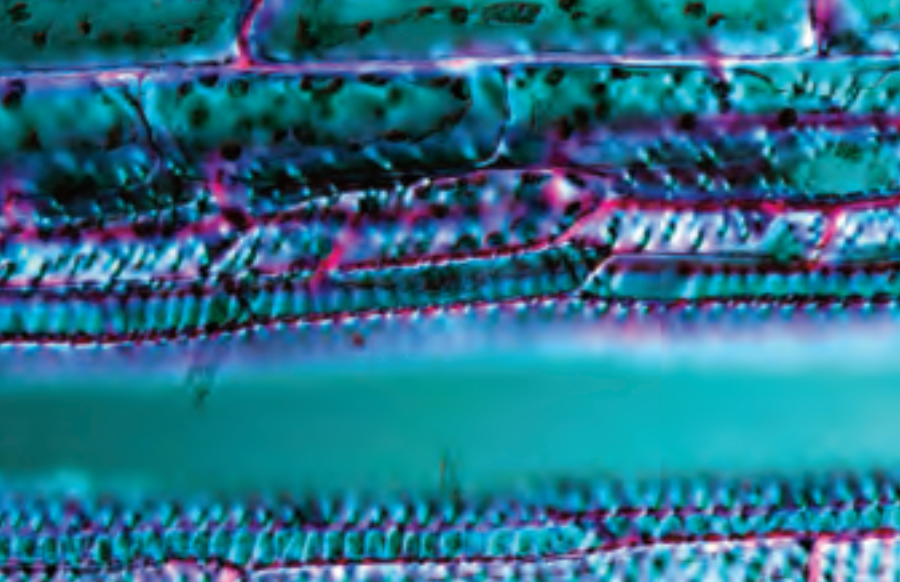


PHOTO: FRANK VENTIMIGLIA, UC DAVIS



►**Top:** Parenchyma cells, which photosynthesize, store, and heal, flank a xylem tube. ►**Above:** Leaves encircle corn's pithy stem, which stores energy. Xylem and phloem vessels shunt water and nutrients.

Casparian strip—are the gates through which every needed molecule must pass.

While root hairs feed the system, the tips of the roots are in constant search of new soil. The root's meristem, or growing point, splits tirelessly, trailing a stream of new cells. The young cells elongate, propelling the meristem forward. A pointed root cap shields the fragile growing point like a copper jacket on a bullet, slicing a path through the soil. Ultimately, it sacrifices its own cells to protect its payload.

Food chain. Those sloughed-off cells—and a soup of sugars and amino acids exuded from the plant—feed a legion of bacteria that teem in the space between the soil and the root. Nematodes and protozoa, microscopic hunters, lurk on the edges of the bacterial herd, picking off prey like lions at a watering hole.

Protozoa, including the shape-shifting amoebas made famous in countless science classes, consume more nitrogen than they need through their bacteria-based diet. They

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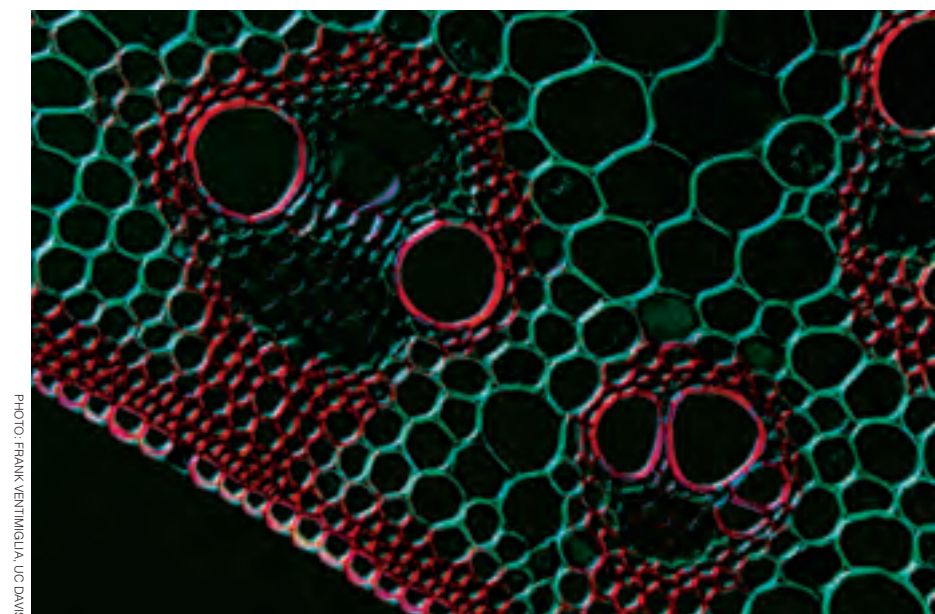
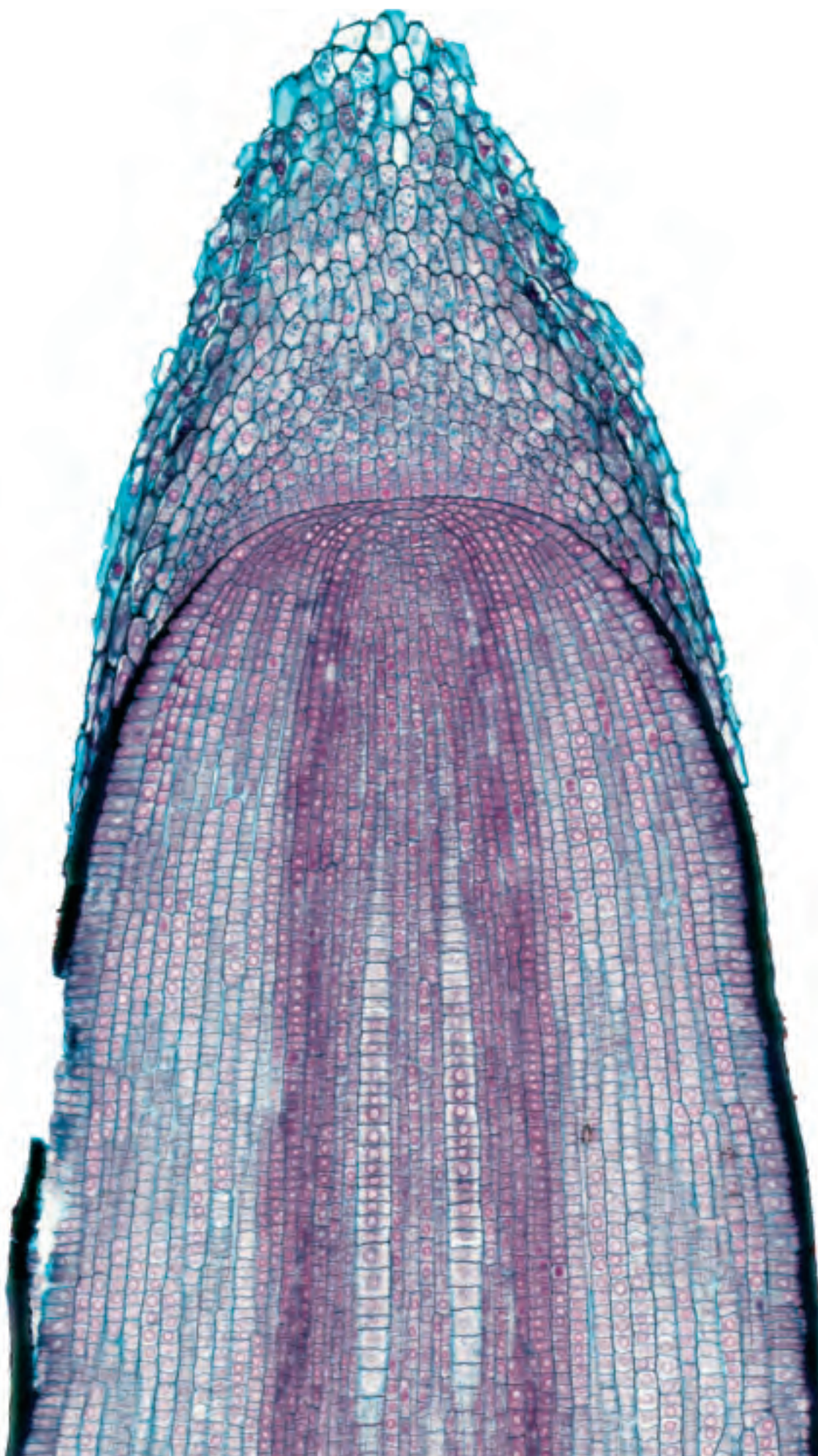


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excrete the excess as ammonium, nourishing the crop as well as more bacteria.

The mass of life and death surrounding the roots—and fostered by them—creates a nutrient-rich zone in easy reach of the root hairs.

Life extends well beyond the roots. An acre of farm ground contains as much as one ton of bacteria; a single teaspoon of topsoil can contain a million bacterial cells. Fungi abound, too, especially where there's fibrous plant residue to digest. Mycorrhizal fungi solubilize phosphorus, and thread-like hyphae—some several feet long—transfer nutrients through the soil like wires conducting electricity.

Priming the pump. As water vapor exits the leaves, it exerts a pull all the way down the vein-like xylem to the roots, sucking in more water and nutrients. The simple physics keeps corn's pump primed and working, building

►**Left:** The bullet-shaped cap protects this root's arched growing point. Elongating cells push the root forward.

►**Top:** Corn's elegant brace roots are nature's flying buttresses. ►**Above:** Xylem "eyes" and phloem "mouths" surrounded by support cells resemble eerie masks in this magnified root cross-section.



►**Above:** A praying mantis snatches prey in 50 to 70 milliseconds—about one-sixth the time it takes to blink. ►**Right:** At his microscope in Davis, Calif., Frank Ventimiglia photographs a corn embryo.

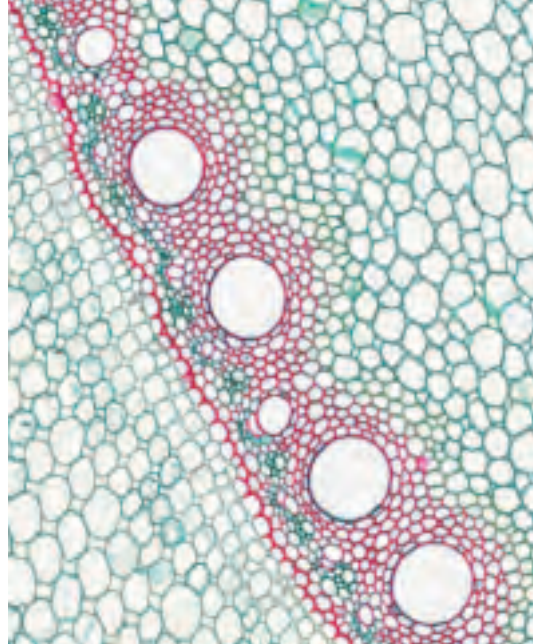


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infrastructure and providing enough excess to store away starch in the ear's precious kernels.

With a steady supply of water and energy from the roots and stalk, the ear begins to form when the plant has three to five leaves.

A developing ear represents nearly boundless potential. It's dotted with as many as 1,000 ovules, each connected to the outside world by its own silk. It takes just one grain of pollen to fertilize each ovule, but corn plants do what they can to tip the odds—a single plant sheds as many as 5 million grains, making 5,000 times more pollen than silks.

If we lived in a perfect world and every ovule grew into a fully mature kernel, the crop could yield as much as 502 bushels per acre, according to a theoretical yield model created by University of Guelph plant physiologist Matthijs Tollenaar. In the real world, highest yields rarely exceed 350 bushels.

Of course, the real world is complicated by less-than-ideal weather, shortages of nutrients and water, and pests that can't resist a towering bundle of sugar, starch, and water.

Fortunately, corn fields are also home to beneficial insects that can't resist a good meal of pests. Every day—and every night, as a U.S. Department of Agriculture study revealed that

►**Top:** The red band in this root cross-section is the gasket-like Casparian strip, which forces all molecules to pass through root cells to reach the gaping xylem. ►**Above:** Cells in embryonic corn leaves form a contoured landscape.

56% of insect predation occurs after dark—there's a life-and-death struggle in the field.

Corn plants under attack from insects release terpenoids, a chemical call for help that attracts beneficial insects. Pest-eating insects can be formidable allies. For instance, a hoverfly larva can consume 300 aphids, then go on to lay 150 eggs. And before the aphids can rest, they'll need to watch out for lacewing larvae, each of which can chew its way through hundreds more of the little suckers.

Meanwhile, wasp larvae parasitize caterpillars, predacious beetles rove the soil, and spiders guard both the high and the low ground.

Closer look. The insects have it right. A corn field is surely worth fighting over.

It's also worth a closer look. Man created this sleek, grain-making dynamo at the dawn of agriculture, and it's paved America's trade routes with gold. Twelve hundred years before European explorers collected corn to bring home from the New World, its roots were already deep in the soil of today's Corn Belt. ■