Dinosaurs may be long gone, but there’s a group of plants far older than the terrible lizards—and they’re still among us. Ferns arose some 400 million years ago, before even our ancestors’ first fin-footed steps on land. However, they’ve received little attention from scientists. “They don’t strike you as a tree does,” says plant physiologist Jarmila Pittermann, who studies the ancient flora at UC Santa Cruz. “No one has really thought about ferns in a way we have thought about other plants.”

Now, inventive research by Pittermann and her colleagues has revealed new details about how ferns function. Their findings have shaken scientists’ perceptions on the plants, and they offer new insights into how ferns transport water. The results have implications for plants around the world as global warming looms.

With more than 10,000 species, ferns are more diverse than any other non-flowering group of plants. They’re also remarkably resilient. They come from a time before plants had flowers, or even seeds. Ferns survived four of Earth’s five mass extinctions as well as the rise of flowering plants, which pushed many other species aside. “I think there are lessons we can learn from [ferns], from the way they’ve made it,” says Pittermann.

Pittermann wasn’t always so fond of ferns. When her research associate Emily Burns first suggested working with the ancient plants within redwood forests, Pittermann wasn’t convinced. “I told her, ‘Emily, that’s great, but there’s nothing to do on ferns, they’re so boring!’” Pittermann says, laughing. However, the idea grew on her. Realizing the unique anatomy of ferns, she hasn’t stopped since. “They’re just so utterly fascinating to me,” she says.

To understand what makes ferns so special, one must look inside and examine their internal “plumbing,” or xylem. The xylem forms a network of microscopic tubes, moving water through the plant. Like veins and arteries carry blood to and from the heart, the xylem carries water from the roots up into the leaves. If the xylem can’t transport water, it can’t keep the plant hydrated, and the plant will die of thirst—or be outcompeted by plants that can do a better job.

Scientists hardly considered ferns the most cutting-edge water carriers because of their ancient vascular system. Ferns were among the first plants to evolve xylem, and many scientists assumed they were largely primitive and unimportant. “The joy of what I do is debunking this,” Pittermann says. She found ferns are just as good at transporting water
as conifers—such as redwoods and pines trees—as well as flowering plants, but in rather different ways.

In conifers and flowering plants, xylem makes wood. For them, xylem pulls double duty, both transporting water and supporting the plant’s twigs and branches. But ferns never evolved wood, so their xylem is structured differently. “This was a real conundrum to me at first,” says Pittermann.

Her research showed that the old plants had some new tricks up their sleeve. Free from the woody confines that shackle what other plants can do, ferns are remarkably adaptable. They arrange their xylem to fit their environment far better than other plants. Ferns form bigger, wider internal conduits when there is more water, and thinner, more water-conservative xylem tubes when water is scarce. Fern xylem cannot transport water as efficiently as more modern plants, but ferns have greater freedom to adapt and arrange themselves in ways that surpass the environmental responsiveness of other plants. “What [ferns] have been able to do with what’s been given to them, to me, is really impressive,” says Pittermann.

Fern xylem even looks radically different. In most plants, the xylem arranges into ring shapes that can eventually turn into wood. A tree's familiar rings are actually millions of microscopic rings of xylem repeated over and over. In ferns, the xylem arrays into bundles that vary from species to species, and even from leaf to leaf. These bundles are staggeringly diverse, resembling Rorschach patterns, smiley faces, and star shapes. This adaptability has been one of the secrets to their success.

No one had ever studied fern physiology in such depth before. “There’s all these ‘a-ha!’ moments,” Pittermann says. “Everything is coming out completely differently than you expected, and you’re realizing, wow, this is a totally new system!”

Pittermann has traveled all around the world to probe the plants, from the tropics to our own backyard beneath the redwoods. One of the more remarkable stories comes from a place that sounds more appropriate for a cactus than any fern: Arizona in mid-summer.

The dusty canyons of southern Arizona in August are challenging habitats for any researcher, let alone a fern. Pittermann and her team found the desert ferns growing in intense sun and scorching heat, perfectly adapted to the arid climate. “It was mindblowing, absolutely mindblowing,” she says. It was also a lot of work. Lugging around heavy equipment and working with the tiny ferns in 100-degree heat, she recalls, “We were all dying of heat stroke.”
Studying plant physiology is challenging, but it’s a useful conservation tool. Pittermann and her colleagues discovered they could gauge the health of redwood forests by looking at the ferns on the forest floor. Acting as a sort of miner’s canary, ferns are among the first plants in the redwood understory to feel changes in water availability. The ferns are so adaptable that they change the shape and structure of their new leaves based on how much water is available. In essence, researchers can use ferns as an early warning system before other plants in the redwood understory respond to changes in water supplies.

Interested observers include the Save The Redwoods League, where Emily Burns serves as science director. The league's ecologists, dedicated to conserving forests in California, keep an eye out for any research that helps them preserve redwood trees. They buy forests to protect the trees from development and logging, but to make sure redwoods will survive and thrive in the tracts they purchase, the league needs a firm grasp of redwood forest ecology and physiology—which includes ferns. “You have to incorporate a common-sense understanding of how plants work into conservation efforts,” says Pittermann. “It’s not just what survives and what we can protect, but how to protect it.”

Ferns offer scientists a unique glimpse into Earth’s past. They have shrugged off mass extinctions, dinosaurs, and ice ages, and they give researchers new perspectives on how plants adapt to stress. Moreover, the fern vascular system exposes how plants, past and present, have evolved to transport water most efficiently. These lessons come at a time when climate change may affect plants in California and elsewhere in ways scientists cannot yet predict.

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