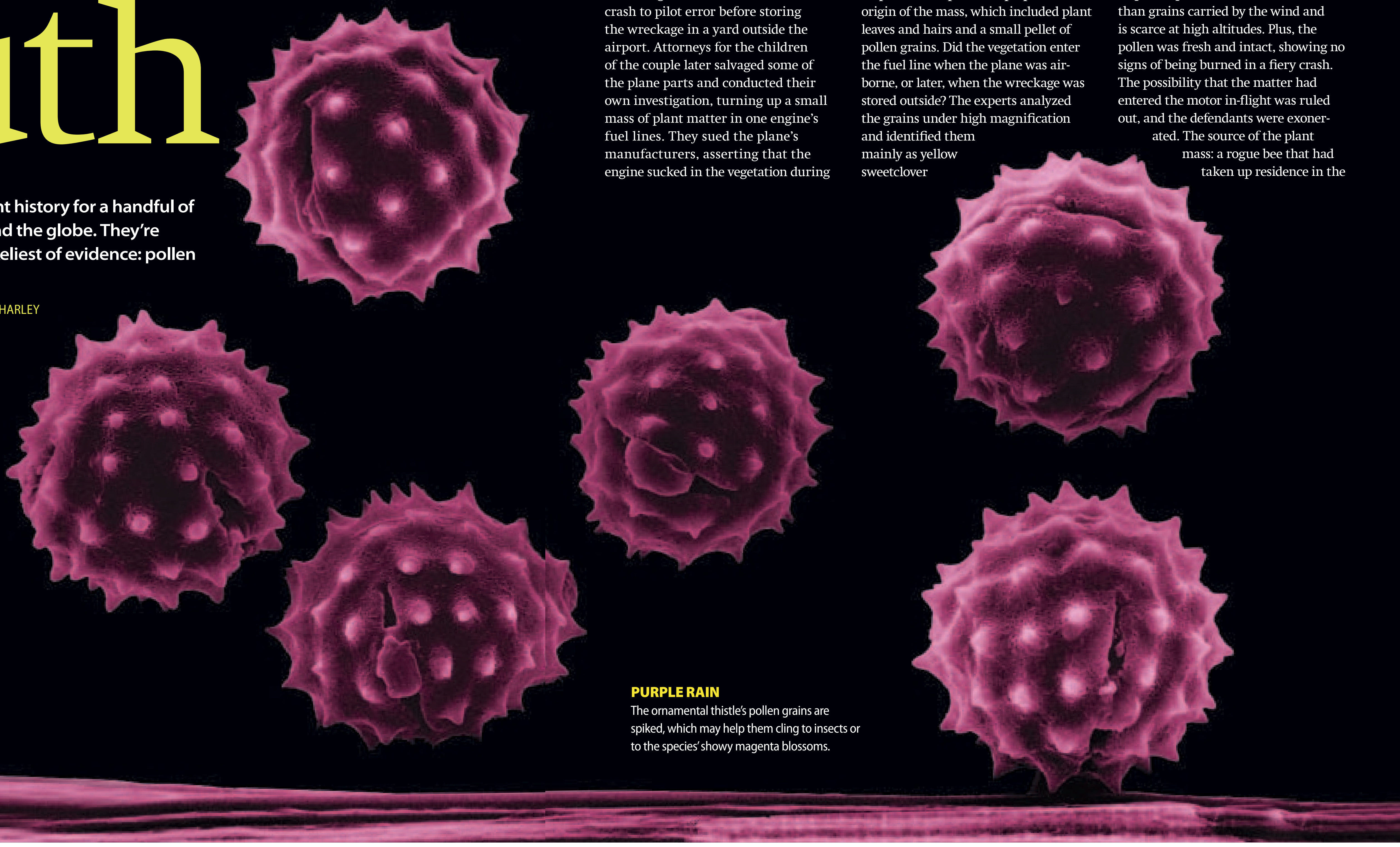
Grains of Truth

Fingerprints? DNA? That's ancient history for a handful of dogged forensic scientists around the globe. They're catching bad guys with the unlikeliest of evidence: pollen

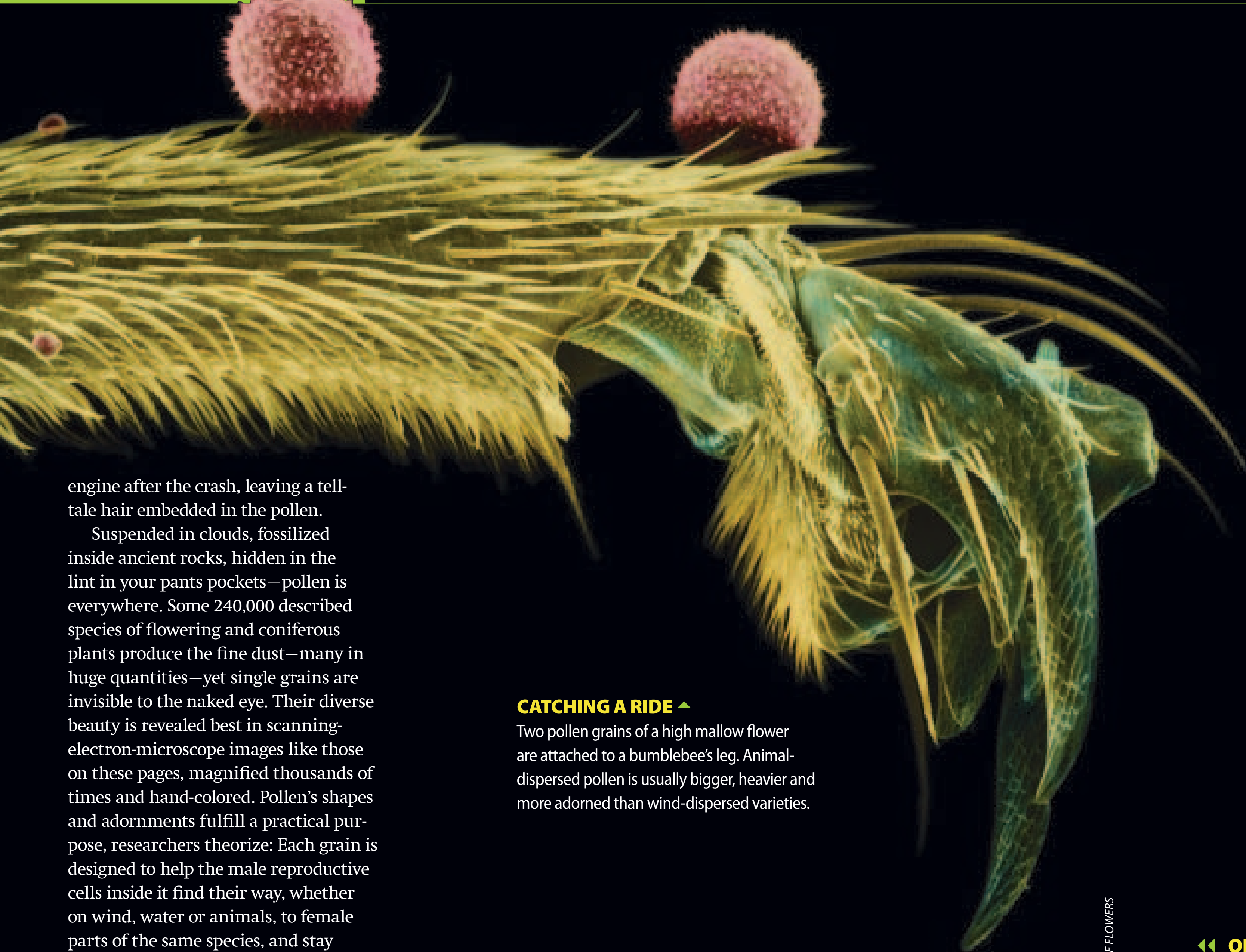
PHOTOGRAPHS BY ROB KESSELER AND MADELINE HARLEY

On December 2, 1989, a private twin-engine plane traveling from San Diego crashed near a regional airport in Ruidoso, New Mexico, killing the pilot and his wife. Investigators found no defects in the engines and attributed the crash to pilot error before storing the wreckage in a yard outside the airport. Attorneys for the children of the couple later salvaged some of the plane parts and conducted their own investigation, turning up a small mass of plant matter in one engine's fuel lines. They sued the plane's manufacturers, asserting that the engine sucked in the vegetation during the aircraft's flight or approach, clogging the fuel line and causing power loss. Filters, they claimed, would have prevented the crash.

In an unusual move, the defense attorneys called in palynologists—experts on pollen and spores—to pinpoint the origin of the mass, which included plant leaves and hairs and a small pellet of pollen grains. Did the vegetation enter the fuel line when the plane was airborne, or later, when the wreckage was stored outside? The experts analyzed the grains under high magnification and identified them mainly as yellow sweetclover and curlycup gumweed, two insect-pollinated flowers that grew in the yard where the plane parts had been stored. Hardly any pollen would have been in the air during the winter when the crash took place, let alone insect-dispersed pollen, which is heavier than grains carried by the wind and is scarce at high altitudes. Plus, the pollen was fresh and intact, showing no signs of being burned in a fiery crash. The possibility that the matter had entered the motor in-flight was ruled out, and the defendants were exonerated. The source of the plant mass: a rogue bee that had taken up residence in the



PURPLE RAIN
The ornamental thistle's pollen grains are spiked, which may help them cling to insects or to the species' showy magenta blossoms.



engine after the crash, leaving a telltale hair embedded in the pollen.

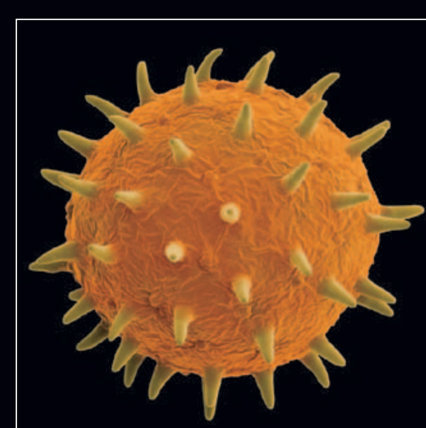
Suspended in clouds, fossilized inside ancient rocks, hidden in the lint in your pants pockets—pollen is everywhere. Some 240,000 described species of flowering and coniferous plants produce the fine dust—many in huge quantities—yet single grains are invisible to the naked eye. Their diverse beauty is revealed best in scanning-electron-microscope images like those on these pages, magnified thousands of times and hand-colored. Pollen's shapes and adornments fulfill a practical purpose, researchers theorize: Each grain is designed to help the male reproductive cells inside it find their way, whether on wind, water or animals, to female parts of the same species, and stay there. Yet lately pollen has begun to play a very different role—as a sophisticated form of forensic evidence.

The Pollen Print

French forensics pioneer Edmond Locard famously stated that every contact leaves a trace. This is a defining principle of forensics. Trace evidence may be clothing fibers, a fingerprint or DNA from blood or hair. Or it could be pollen.

Bees, like other animal pollinators, pick up the grains as they travel from flower to flower, collecting nectar

CATCHING A RIDE ▲
Two pollen grains of a high mallow flower are attached to a bumblebee's leg. Animal-dispersed pollen is usually bigger, heavier and more adorned than wind-dispersed varieties.

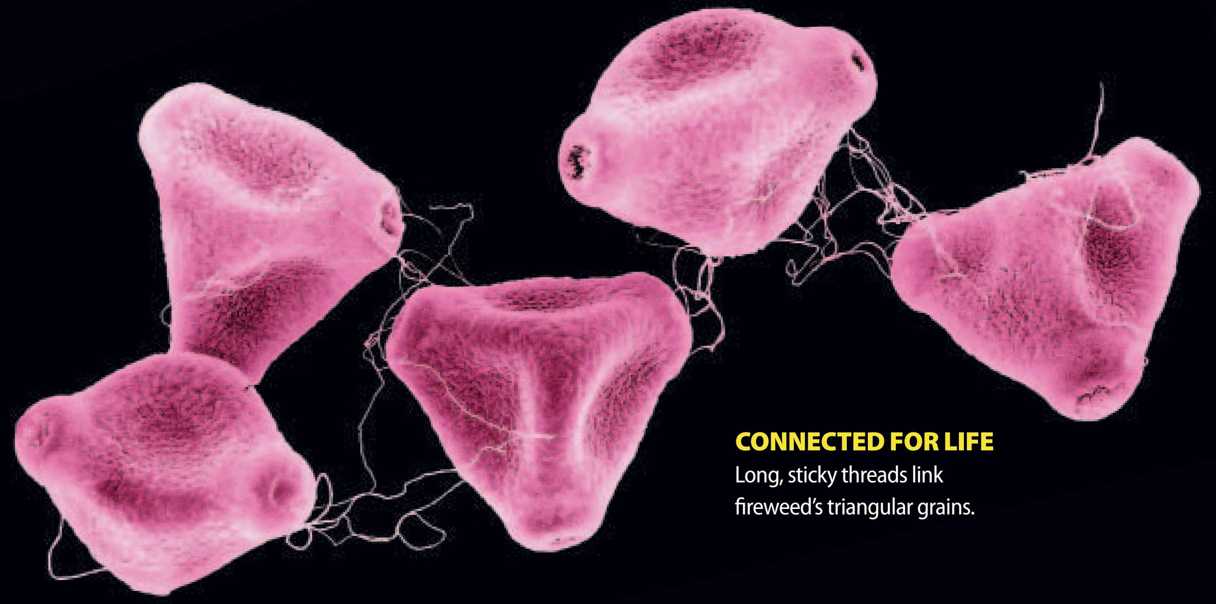


PAPADAKIS PUBLISHER, FROM *POLLEN: THE HIDDEN SEXUALITY OF FLOWERS*

◀◀ OPEN WIDE
Most pollen, like that of the pinang palm, has one or more apertures, openings covered by membranes that burst under pressure from its pollen tube [not shown]. Reproductive cells travel down the tube to the ovule of a receptive flower.

◀ PRETTY PRICKLY
The apertures are closed on this ginger-bush grain and appear as small bumps between spines.

POLLEN PARACHUTES
The wind-dispersed grains of the Douglas fir, commonly used for Christmas trees, rely on air-filled sacs [yellow] to stay afloat.



CONNECTED FOR LIFE
Long, sticky threads link fireweed's triangular grains.

and pollen for food and nest building. Pollen grains that travel on animals tend to be relatively large (up to 200 microns, or 0.008 inch, across) and can be elaborately adorned. These adornments may have evolved to help the grains attach to animals or to the stigma, the female receptive organ on a flower. Wind-dispersed pollen is usually smaller (five microns at its tiniest), smoother and more plentiful, but it's no less striking. A glance at the grains in a scanning electron microscope explains why palynologists refer to pollen's artful topography as "sculpture."

Surprisingly, not all pollen is spherical. Some is disc-like, some football-shaped and some triangular. The pollen of a particular species even differs from that of its closest relatives. Spores, the reproductive cells of the planet's roughly 26,000 described ferns, mosses and other primitive, asexual plants, also vary from one another. All this diversity of shape and size means there's a different "fingerprint" for every plant in the world. These fingerprints are the domain of forensic palynologists, a small group of experts who use pollen and spores to link objects and people to crime scenes.

And just as every plant has its own fingerprint, every location too has a distinct "pollen print," the assemblage of different types of pollen and spores present on the scene. Matching the pollen print from a crime scene to samples found on a suspect's belongings may place the person at the scene. If a suspect denies having been there, pollen may show that he's lying. And if a victim and suspect have the same pollen profile on them, it can often be concluded that both were at the same place at the same time. "Pollen is one of the most powerful techniques in trace and contact evidence," says Patricia Wiltshire, a forensic ecologist, botanist and palynologist at the University of Gloucestershire in England, which leads the world in the use of forensic palynology.

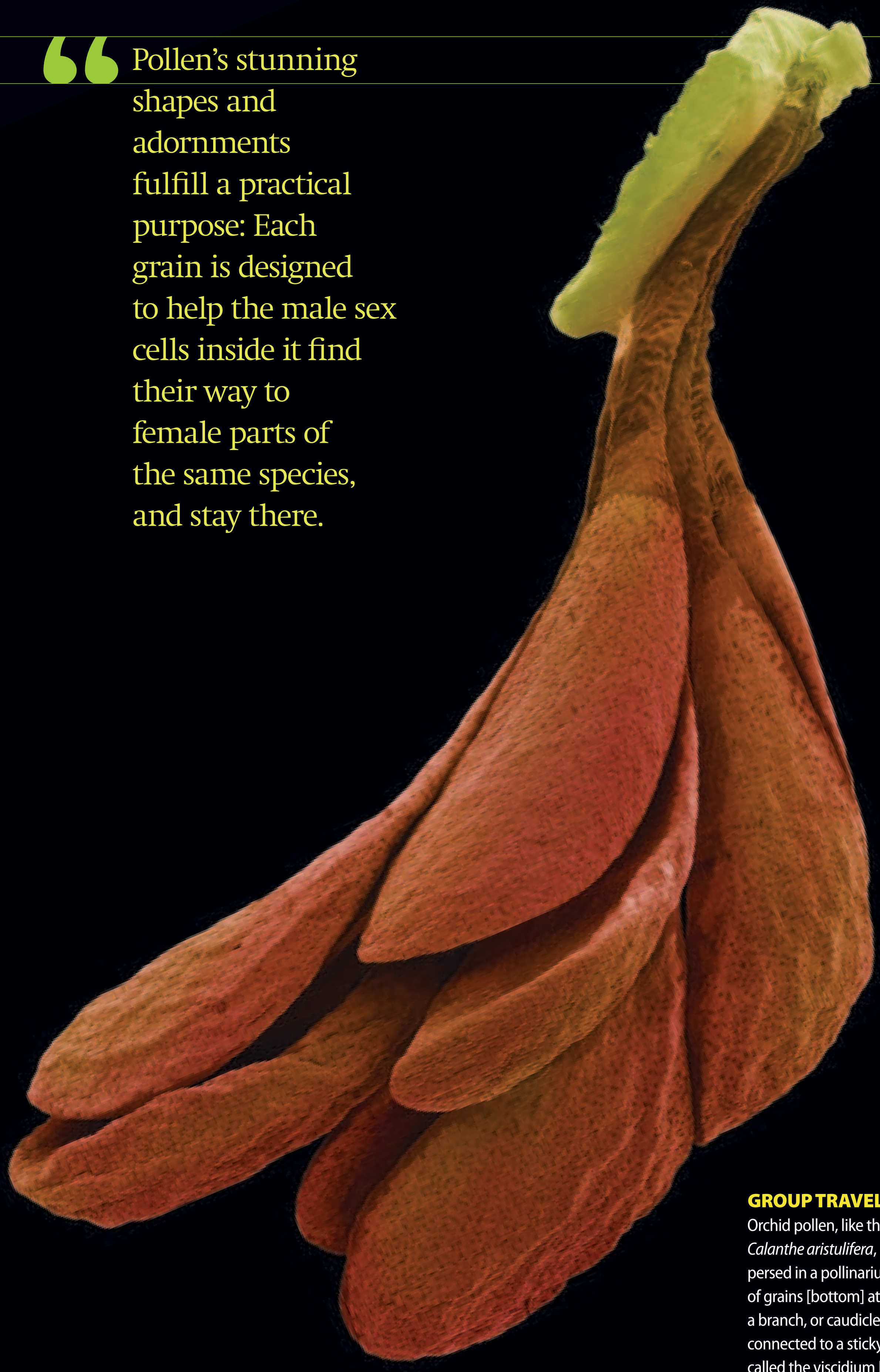
Beautiful Tool

Last year, Wiltshire used pollen to convict three drug dealers for murdering a drug runner. "It was a spectacular case," she says. "One of the gang hid behind an oak tree within a cypress hedge. We showed that the palynological assemblage in samples from the crime scene—from leaf litter, soil, washings from the oak tree trunk and from foliage on the cypress hedge—was very similar to that on the clothes, shoes and vehicles retrieved from the suspects. There were a number of rare plant pollens that were in the soils at the scene that matched some on the exhibits." All three of the suspects were found guilty, thanks in large part to Wiltshire's pollen analysis, and sentenced to life in prison.

DNA, the current darling of forensics, is faster to process than a pollen assemblage, which must go through a painstaking chemical treatment to remove the material surrounding it and the cytoplasm and sex cells inside it and then be carefully analyzed through a microscope to identify each individual species. Palynologists can determine a plant group—spruce trees, for example—using a standard light microscope at up to 1,500 times magnification. More time-consuming and expensive is the higher-resolution scanning-electron- or transmission-electron-microscope analysis that's sometimes needed to identify a plant species. So why bother with pollen? "The problem with a single hair is, how did it get there?" explains Dallas Mildenhall, a principal scientist at the forensics lab GNS Science in New Zealand. "Couldn't it have blown in from the window? But when you're dealing with a large number of pollen grains, the chances are highly likely that they were transferred at a precise time."

"For a while, DNA was God," adds Lynne Milne, Australia's leading forensic palynologist at Curtin University of Technology. "It almost seemed

> "Pollen's stunning shapes and adornments fulfill a practical purpose: Each grain is designed to help the male sex cells inside it find their way to female parts of the same species, and stay there.



GROUP TRAVEL
Orchid pollen, like that of *Calanthe aristulifera*, is dispersed in a pollinarium, a group of grains [bottom] attached to a branch, or caudicle [middle], connected to a sticky structure called the viscidium [top].

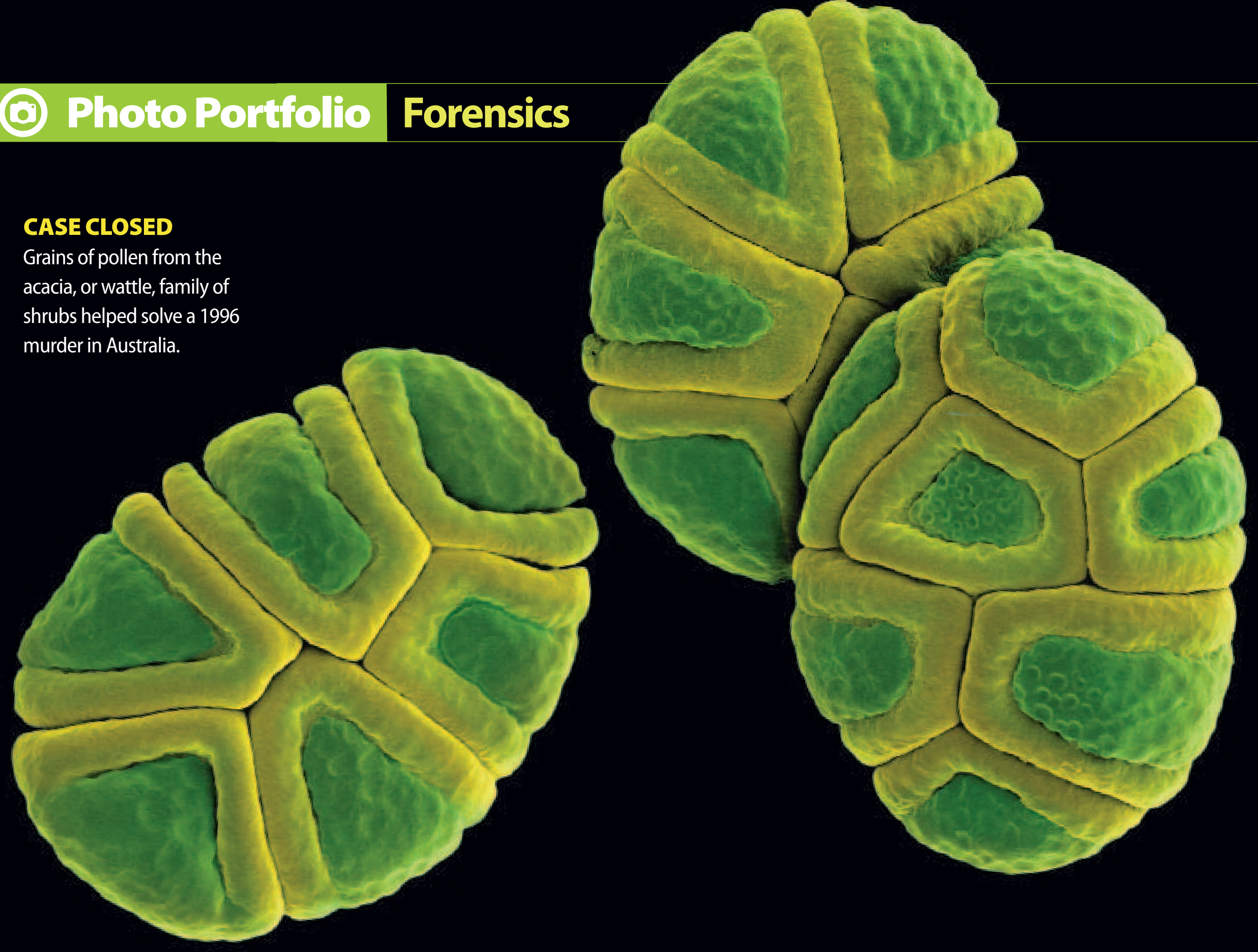
like if there was no DNA, there was no evidence. But now people are looking at it differently." One of pollen's greatest advantages for forensics is its microscopic size. Criminals don't realize they've taken it with them or left it behind. In Milne's first case, in 1997, a man washed his clothes after murdering his estranged wife. Laundering the clothes didn't succeed in eliminating the trace evidence on it. Milne still found an uncommon type of acacia-shrub pollen on his shirt clearly linking him to the woods where he had dumped his wife's body and to the car that had been used to get there.

The Coldest Cases

Pollen's cell walls are very durable, so the grains can survive for millions of years. In one case in Wales, pollen from a walnut tree that had been cut down 80 years prior linked suspects to the scene of a crime where the tree had once stood. The pollen had persisted in the soil and made its way into the suspects' vehicle. Pollen's longevity makes it especially useful for investigating cold cases, like the mysterious identity of a teenage girl murdered in a cornfield in upstate New York in 1979. Twenty-seven years later, in 2006, palynologist Vaughn Bryant, the director of the palynology lab at

TAKING FLIGHT
Pollen is produced in anthers, the sacs on the tips of the stamen, the male organ of flowers.

SHIRT TALES
Pollen on clothing, like these silk-tree grains trapped on the fibers of a cotton shirt, can link people to crime scenes. This species sheds polyad pollen, in which grains are packaged in groups of four or more.



CASE CLOSED
Grains of pollen from the acacia, or wattle, family of shrubs helped solve a 1996 murder in Australia.

Texas A&M University, analyzed her clothing and found pollen that occurs only in the southwestern U.S., possibly around San Diego. This supported the local police's belief, based on other evidence, that she was from the southwest, not the northeast. "Pollen is an incredible tool and resource," says Livingston County sheriff John York, who is still searching for the girl's identity. "We can always suspect where a person came from, but to have definitive proof is another thing."

The U.S., with its huge diversity of flora and extensive pollen records, is ideal for forensic palynology. The field debuted here in the mid-1970s, when the Department of Agriculture first used pollen to ensure that beekeepers receiving domestic subsidies were actually making their honey in the U.S. But it's only been used in a handful of criminal cases here since then. "Local law-enforcement agencies don't know about it or don't believe it's useful," Bryant says. "Or they don't want to pay for it."

Interest has grown at the federal level since 2001. "After 9/11, Bryant says, "the U.S. government was eager to do anything to find out who had committed the attacks and to prevent it from happening again." Pollen has since been used in several terrorism investigations. Although he couldn't comment on the cases, Bryant hinted at their nature: "Pollen is a very good telltale for where things come from." The burned clothing of suicide bombers, for example, may retain pollen that could hold clues to their origin. Pollen has also been used to investigate war crimes. In the late 1990s, forensics experts working with the United Nations in Bosnia found pollen evidence indicating that more than 2,000 Bosnian Muslim men and boys executed over five days in 1995 during the Bosnian war had later been moved from five large mass graves to several smaller ones scattered across the countryside to cover up the massacre.

Yet pollen's purview extends far beyond violent crimes. Around the world, it has been used to break up a cocaine ring, authenticate antiques, find counterfeit Viagra and antimalarial drugs, and even track down stolen sheep and a lawn mower. Pollen's seemingly limitless versatility is one more reason why it's a crucial addition to the forensics toolbox.

And it won't be the last. A few years ago, a fungus expert, or mycologist, named David Hawksworth advanced Wiltshire's work by sharing his knowledge of fungi, whose spores, like those of plants, can link objects and people to crime scenes. Mold can also be used to determine time of death when other clues, like flies swarming a corpse, aren't present. Hawksworth and Wiltshire later married, and today the two are championing the use of ecological evidence in forensics. Pollen and fungi evidence have bolstered each other in some cases, Wiltshire says. Fungus, it seems, is the next frontier. ■

BEHIND THE SCENES
The scanning electron micrographs in this story were captured by visual artist Rob Kesseler, a former fellow at the Royal Botanic Gardens, Kew, in England, and Madeline Harley, the former head of the palynology unit at Kew and a current research fellow there. Kesseler colored the black-and-white images—including the group on this page, from his car's air filter—by hand. "My coloration is based on the flower color and adjusted to give the form a stronger feeling of three-dimensionality while also indicating different functional characteristics of the pollen grain," he explains. "I spend a lot of time building up subtle layers of color to create the final image. Although I use a graphic pen and drawing tablet, the artistic sensibilities are in many ways no different than when I draw with pastels or paint with watercolors."