organs, were spending too much time in their first two developmental stages: the vegetative phase, when they build leaves, and the inflorescence phase, when they build the stems that will later bear flowers.

At first, Ray didn't suspect that the mutation was having a direct effect on flower-building. He thought it might simply be altering the plants' response to changes in day length, which normally trigger flowering. But he found that short-day conditions led to a similar slowing of growth in normal and mutant plants, an indication that the mutants' responses to day length were intact. Next, Ray and colleagues Jean Lang, Teresa Golden, and Sumita Ray crossed the mutant plants with other mutant strains to test whether the protein encoded by *SIN1* is a required component of some other regulatory pathway known to affect the timing of flowering. The results suggested that it isn't.

For example, investigators had already identified a gene called *Terminal Flower 1* (*TFL1*)—because mutations in the gene produce plants in which the central meristem is capped by a flower rather than remaining indeterminate—that apparently suppresses the expression of floral organ-building genes such as *LFY* and *AP1*. The transition from stem-building to flowering occurs when still other genes down-regulate *TFL1*, increasing expression of the flower-building genes. But plants bred to have mutations in both *SIN1* and *TFL1* produced 19 leaves on average, as opposed to six for plants with a mutation in just *TFL1* and 25 for those with a mutation in just *SIN1*. This intermediate result indicates that there is no direct interaction between the two genes. And that leads Ray to speculate that *SIN1* is a master timekeeper gene—hurrying the meristem on its journey toward flowerhood by regulating its ability to respond to other genes, such as *LFY*.

Ray is hoping to test this timekeeper hypothesis by cloning the gene. With both the gene and its protein product in hand, the researchers will be able to chart exactly when and where the gene is expressed during development—and whether its activity shows a telltale overlap with that of other genes involved in flower development. "If one found similar expression patterns," says Weigel, "that would certainly make a very strong point" that ovules set the pace for flower development—in the Cretaceous and every time an angiosperm blooms today.

–**Wade Roush**

PALEONTOLOGY

Viewing Velvet Worms in Amber

Paleontologists are accustomed to piecing together an animal's evolutionary history from fragmented clues. But there are times when the dots are too far apart for even a paleontologist to join. That is the case for velvet worms, odd little invertebrates that look like rolled Persian carpets with legs and may represent an evolutionary link between annelids, the familiar segmented worms, and the wildly diverse arthropods, the phylum that includes insects. Today velvet worms, or onychophorans, are land dwellers up to 15 centimeters long that roam the forests of the Southern Hemisphere. In contrast, the fewer than 30 known velvet worm fossils are mostly marine, all from the Northern Hemisphere—and all are at least 300 million years old. That leaves a wide gulf in space, time, and lifestyle for paleontologists to bridge.

A report on page 1370 "fills in part of that gap," says Doug Erwin, a paleontologist at the National Museum of Natural History. In it, entomologist George Poinar of Oregon State University describes two velvet worm specimens entombed in chunks of amber, 20 million to 40 million years old, from the Baltic region of Europe and the Dominican Republic. The finds don't settle the problem of the velvet worm's family relationships. But the locations of the discoveries, and the fine details of the onychophoran head and appendages on view in the amber, offer what Erwin calls a "wonderful view" of worms that are intermediate in time between the ancient fossils and living animals.

Previously known onychophoran fossils come from sites with spectacular preservation of soft-bodied animals, such as the 530 million year old Burgess Shale of British Columbia and the 300 million year old Mazon Creek formation of Illinois. All of the fossils are found in marine rocks, although the Mazon Creek sediments were deposited close enough to shore that the animals may have washed in from land. All recent velvet worms, however, are unambiguously terrestrial and have a critical adaptation for life on land: a slime pore that squirts a sticky substance used both to entrap prey and fend off predators. And they live on the opposite side of the world from their ancestors, inhabiting forest floors throughout the Southern Hemisphere.

The 40 million year old Baltic fossil, likely the older of the two, provides the first solid example of onychophorans on land and, because it is from northern Europe, proves that terrestrial velvet worms did indeed once roam the Northern Hemisphere. This suggests that unless the animals managed to adapt to land twice, terrestrial forms evolved while all the continents were connected, before the breakup of the supercontinent Pangaea about 180 million years ago, says David Briscoe, a velvet worm expert at Macquarie University in Sydney, Australia. And the dates on the new fossils show that onychophorans survived in the Northern Hemisphere for more than 140 million years before mysteriously becoming extinct.

D. ERWIN

G. POINAR

J.W.O. BALLARD

Bridging the gap. The gulf between ancient velvet worm fossils *(top)* and the living animals *(bottom)* may be bridged by new specimens trapped in amber.

The fossil from the Dominican Republic, meanwhile, displays an intriguing combination of primitive and modern features, says Poinar, with the head of modern velvet worms but legs that resemble ancient forms. Modern velvet worms walk on fluid-filled legs ending in "feet" with roughened pads and claws. In contrast, the legs on the ancient fossil onychophorans—and the Dominican fossil—sprout claws but show no evidence of distinct feet, Poinar says. But the Dominican fossil apparently possessed slime pore glands on its head, as modern worms do. In fact, Poinar found thick deposits extending from openings on the head, which he theorizes contain the slime expelled when the worm found itself caught in the amber-forming tree sap.

The obvious next step in exploring velvet worm evolution is to sample the fossils' DNA, which the amber may have preserved. Poinar says he prefers to wait until more specimens are found, however, for such sampling can be destructive. But without such genetic data, other paleontologists note that even with the new fossils, the record of velvet worms is just too sparse to draw an evolutionary chain from 300 million years ago to the present. Briscoe and Macquarie colleague Noel Tait say that the amber specimens may be a side branch that broke off shortly after the move onto land. "With this kind of group all you get is little snapshots occasionally," Erwin says. But at least now researchers have a couple of exceptionally clear snapshots to study.

–**Gretchen Vogel**