Monkeyflowers: A Leap for Nature?

In this age of concern over the loss of species, scientists are still debating how speciation—the appearance of new species—works. Must many small genetic mutations occur or do a few genes undergo big changes? Darwin argued that change occurs gradually and that "natura non facit saltum"—nature does not make leaps. But a new study suggests otherwise.

Recent research on the wildflower *Mimulus*, also known as the monkeyflower, suggests that new species arise largely through mutations in a handful of genes with key functions, according to Toby Bradshaw and his colleagues at the University of Washington in Seattle.

The team's subjects, *Mimulus lewisii* and *M. cardinalis*, grow widely in and west of the Rocky Mountains. They have many different features, including the color and shape of their flowers, and the quantity and concentration of nectar they store. Although neighbors, they can't interbreed, as only hummingbirds pollinate *M. cardinalis* and only bumblebees spread the pollen of M. *lewisii*. However, scientists can crossbreed them in the laboratory.

What genetic changes—and how many of them—caused these monkeyflowers to develop such unique traits? To find out, Bradshaw and his colleagues employed genome mapping techniques now popular among plant and animal breeders.

The scientists mapped much of the genome of a hybrid of the two species. In the process, they determined which genes influenced traits related to pollination: such as flower color, size, and shape; nectar volume and concentration; and pistil and stamen length.

In the Aug. 31 NATURE, they report finding that for each trait, at least one gene proved responsible for more than 25 percent of the variation within a sampled population of hybrid flowers. For example, *M. cardinalis* produces 80 times more nectar than *M. lewisii*, and a single gene causes at least half of that difference. Bradshaw suspects that other, unidentified genes control each trait's remaining variation.

Bradshaw

J. Rehm/ Univ. of Wash.

A hummingbird visits Mimulus cardinalis *(above and below right) but won't pollinate* M. lewisii *(below left)*

M. cardinalis' red color, which results from high concentrations of anthocyanin and carotenoid pigments, attracts hummingbirds but goes unnoticed by bumblebees, which, Bradshaw points out, don't detect red. *M. lewisii's* pale pink petals have a low concentration of anthocyanin and attract bumblebees. Bradshaw and his colleagues found that one gene causes nearly one-quarter to one-third of the difference in anthocyanin concentrations, while a single gene determines the presence of carotenoids.

"There is now increasing evidence for the importance of major genes," asserts Jerry A. Coyne of the University of Chicago, writing in an accompanying editorial. "There are still only a handful of relevant studies, of which the best is now [Bradshaw's] work on *Mimulus*."

Before this work, no other team had looked at several traits of two species simultaneously and examined a large number of regions on the chromosomes to study how plants evolve in the wild, says Coyne.

Although speciation in this one flower seems traceable to differences in a few genes, researchers will need to do many more such studies to say definitively whether speciation generally involves mutations in a few or in many genes, says Loren H. Rieseberg of Indiana University at Bloomington.

Indeed, the question has remained unanswered for so long, the Seattle team asserts, largely because detailed genetic studies have been limited to only a few species, such as fruit flies. — *T. Adler*

Imaging electric, magnetic microfields

Sprinkle iron filings across a sheet of paper covering a bar magnet, and the filings align themselves to reveal the shape of the magnetic field around the magnet. But what do you do if the magnetized object itself is considerably smaller than an iron filing?

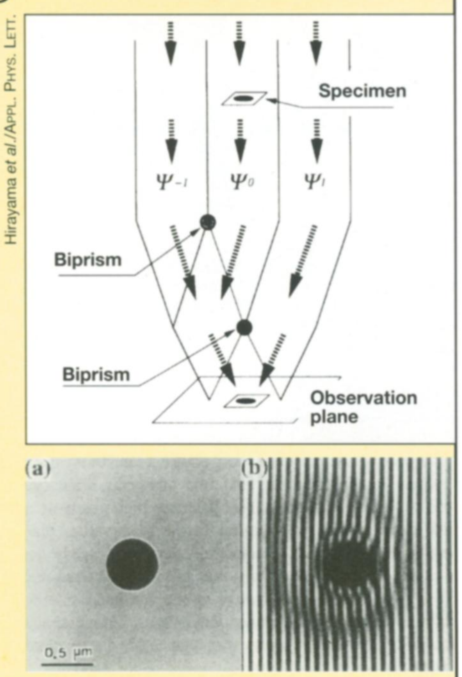
Researchers have now developed a new method based on electron microscopy for directly visualizing the fields surrounding tiny, electrically charged or magnetized particles.

Akira Tonomura and Takayoshi Tanji of the Hitachi Advanced Research Laboratory in Saitama, Japan, and Tsukasa Hirayama of the Japan Fine Ceramics Center in Nagoya describe their novel imaging technique in the Aug. 28 APPLIED PHYSICS LETTERS.

Tonomura and his coworkers rely on the fact that electrons can exhibit both particle and wave behavior. Using an electron microscope, they generate three electron waves (see diagram), which combine to reinforce and cancel each other out at different places, creating a distinctive interference pattern. Placing an electrically charged or magnetized specimen in the path of the central beam distorts the pattern, revealing the field around the particle.

Using this technique, the researchers have observed the electric field around a microscopic latex particle and magnetic field lines around a barium ferrite particle. — *I. Peterson*

Hirayama et al./APPL. PHYS. LETT.



Top: A combination of precisely aligned lenses (not shown) and electron biprisms (which act like double slits) brings three electron waves together to form an interference pattern, which can then be photographed. Bottom: Electron micrograph of a latex particle on a thin carbon film (a). Charging up the particle creates an electric field, which shows up as a distortion in the interference pattern (b).