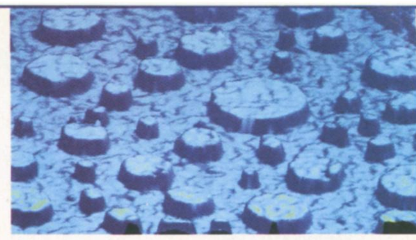
Friction reveals chemical composition


Overney et al./NATURE

Friction force microscope image shows hydrocarbons in a fluorocarbon sea.

A new type of atomic force microscope now lets scientists tell in molecular detail not only what a surface looks like, but also the distribution of its chemical components.

The technique, which takes advantage of differences in the friction forces exerted by various materials, may prove useful for chemical analysis, characterization of mixtures of molecules, and studies of wettability and friction, says Jane Frommer, a chemist with the IBM Almaden Research Center in San Jose, Calif.

Typically, scientists monitor the vertical shifting of the very fine tip of an atomic force microscope (AFM) to image the surface of a sample. Then in 1987, IBM researchers discovered that the sideways deflection of the tip was indicative of friction between the tip and the surface, and they modified an AFM to make a "friction force" microscope, Frommer says.

Now, working with physicist Hans-Jorg Güntherodt and his colleagues at the University of Basel in Switzerland, Frommer has demonstrated that this microscope can distinguish materials based on the friction forces exerted by clusters of molecules. "We use the lateral response [of the tip] to differentiate between species in surfaces with more than one compound," she says.

To explore this potential, the Swiss group obtained special films from Masamichi Fujihira, a chemist at the Tokyo Institute of Technology. Fujihira's group makes these films by dipping a silicon plate into a solution of hydrocarbon and fluorocarbon molecules. The resulting film consists of discrete islands of hydrocarbon in a sea of fluorocarbon, Frommer notes.

Until now, scientists have mapped the chemical makeup of such a film by adding fluorescing dyes that some components in the sample absorb more readily than others. Then the researchers examine the distribution of dye with fluorescence microscopy. But the resolution of the friction force microscope is hundreds of times better; it sees features on the scale of angstroms as opposed to microns, says Frommer.

The friction force microscope revealed that "there are indeed subdomains that are down under the micron scale," says Frommer. In one supposedly single-layer sample, the researchers detected that hydrocarbon clumps actually floated on top of the fluorocarbon molecules.

The fluorocarbon molecules exert four times the friction force of the hydrocarbon clumps, and the silicon exerts 10 times as much, Basel graduate students Rene M. Overney and Ernst Meyer and their colleagues report in the Sept. 10 NATURE.

"We aren't claiming to have absolute measurements of friction," Frommer cautions. "What's important is the contrast between the areas." The researchers do not know what property of the molecular clusters creates this sideways deflection in an AFM tip, but they expect to use the technique to study friction and lubrication on a molecular scale. Also, friction force microscopy may have commercial application for studies of heterogeneous materials such as analyses of the distribution of the chemical elements in membrane filters or the degree of mixing of new additives in petroleum products, says Frommer. *— E. Pennisi*

Preserved DNA reveals lineage of moas


J. Skalla/EXPLORE

Extinct moa

Centuries have passed since the last species of moa died, yet scientists have only now begun to unravel the genetic code of these extinct birds. By comparing ancient DNA samples extracted from moa remains with DNA samples from modern birds, researchers can put the moa in its proper place on the evolutionary tree.

This genetic study "sheds new light on the origins and evolution of these birds," says Alan Feduccia, an expert on avian evolution at the University of North Carolina at Chapel Hill.

Traditionally, biologists have placed the flightless moa with the modern ratites, the taxonomic group that includes other flightless birds such as ostriches and kiwis. Researchers have continued to argue, however, about the moa's exact connections to members of this group.

Debate has focused in particular on the evolutionary relationship between moas and kiwis; many researchers have proposed the moa as the kiwi's closest relative.

Like the modern kiwis, which resemble a large chicken in size, moas were restricted to New Zealand. However, moas ranged from the size of a large turkey to over 3 meters high. Isolated from mammalian predators by the waters surrounding their home, moas prospered for millions of years. With the arrival of the first aboriginal people, however, moas began to decline until they became extinct several hundred years ago.

Modern biologists have had to reconstruct moa taxonomy indirectly from preserved bones and rare tissue samples — until now.

An international team of scientists has extracted and sequenced DNA fragments from ancient moa remains. This allowed the researchers to compare the genetic structure of the moa directly with that of modern birds, revealing that the moas differ in their origins from the kiwis. Details of this study appear in the September PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES.

The researchers conclude that, while clearly members of the ratite group, moas diverged from other ratites early in their evolution. Kiwis, on the other hand, appear closely related to the modern ratites of Africa and Australia. These divergent origins of New Zealand's birds raise the possibility that flightlessness evolved several different times among the ratites, the scientists conclude.

The team compared DNA fragments extracted from the remains of four different species of moa with comparable DNA sequences from eight modern species of ratite birds.

While similar studies have examined isolated samples from ancient animal and human remains (SN: 4/27/85, p.262), this is the first to look at DNA from both bone and tissue samples preserved under similar conditions, says team member Svante Pääbo, a molecular biologist at the University of Munich in Germany. The researchers found that DNA seems to survive longer in bone than in soft tissue, perhaps because the minerals in bones may bind to DNA molecules, Pääbo says.

The oldest DNA obtained came from a moa specimen approximately 3,300 years old, which had been naturally mummified in a dry cave. Few ancient remains still yield identifiable DNA, because DNA eventually breaks apart in the presence of water and oxygen, explains Pääbo. He predicts that similar studies may soon reveal the evolutionary history of saber-toothed tigers from the tar pits of Rancho La Brea in Los Angeles, Calif., as well as frozen mammoths from Siberia. Pääbo plans next to conduct a taxonomic study using DNA from the remains of extinct cave bears in Europe. *— K. Hoppe*