Wet side story: On adhesive failures

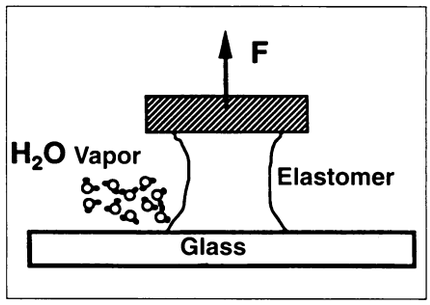
Moisture has a devastating effect on the stickiness of many adhesives. High humidity can reduce the durability of epoxies used to bond metal, exposure to water can render pressure-sensitive sealing tape ineffectual, and sweat can readily loosen the grip of an adhesive bandage.

"Water is a severe problem for all kinds of bonding," says physicist J. Thomas Dickinson of Washington State University in Pullman.

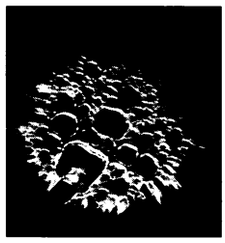
Now, Dickinson and his coworkers have constructed a special apparatus to investigate the effect of humidity on adhesives, providing insights into water's role in weakening these materials. Their results indicate that water attacks a bond most effectively when the adhesive is stretched beyond a certain threshold.

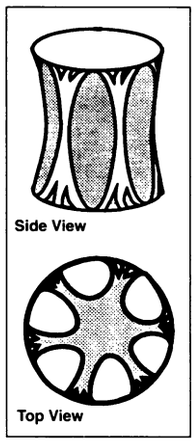
"It was our most surprising finding," Dickinson says. "If the [stretching] force isn't high enough, the attack won't occur."

In their initial experiments, the researchers used a tiny drop of a polyisoprene-based adhesive obtained from a commercial brand of transparent packaging tape. Compressing the drop between a metal and a glass plate, then pulling the plates apart, they could observe the adhesive's response to rapid changes in humidity and measure the force acting between the plates throughout the process.



Dickinson





Stretching a drop of adhesive between two plates (top) creates voids within the drop, and fingers and cavities along its perimeter (right).

In dry air, as the plates separate, voids form within the adhesive blob. The material elongates, creating a distinctive pattern of fingers and cavities along the drop's circumference (see diagrams, photo). Eventually, the bond breaks.

Water hastens this process by attacking the adhesive from the outside, particularly as the material starts to stretch into long fingers. Once the adhesive begins to yield under these conditions, it moves toward failure rapidly.

"Failure always starts at the perimeter, in the outer fingers, where tensile stresses are high," Dickinson remarks. "They're the most vulnerable part."

However, if the stretching force stays below a critical value, the presence of water has no noticeable effect on the bond's durability. At the same time, no attack occurs if the ambient humidity is less than a certain level. The researchers have obtained similar results for other adhesives, including acrylate-based formulations used in household tape.

The explanation of water's effect may lie in its electric influence on the adhesive and the surface to which it bonds. Normally, a weak electric attraction keeps an adhesive and surface joined together. But the presence of water molecules can alter the distribution of electric charge in both the adhesive and the surface, making them repel each other to disrupt the bond.

"The normal mechanisms of adhesion are swamped out by the water," Dickinson says. He described his team's findings at last month's American Physical Society meeting, held in San Jose, Calif.

— I. Peterson

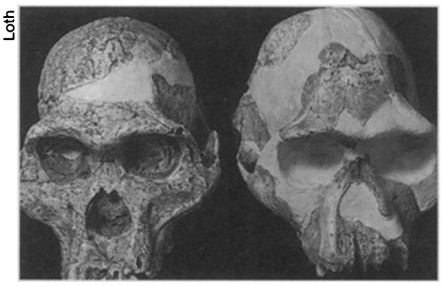
Hominid skull gets abrupt sex change

About 50 years ago, the Sterkfontein site in South Africa yielded the nearly complete skull of a hominid, or member of the human evolutionary family. Given its relatively small size, the 2.5-million-year-old *Australopithecus africanus* individual was dubbed "Mrs. Ples," a nickname it still retains.

But a new method for identifying the sex of fossil hominids indicates that this skull is male and thus deserves the title "Mr. Ples." The same method tags another, larger *A. africanus* skull from Sterkfontein as female, asserts Susan R. Loth of Florida Atlantic University in Boca Raton.

Loth collaborated with South African researchers Maciej Henneberg of the University of the Witwatersrand Medical School in Parktown and J. Francis Thackeray of the Transvaal Museum in Pretoria. She presented her findings last week at the annual meeting of the American Association of Physical Anthropologists in Oakland, Calif.

"When it comes to sex, size isn't everything," Loth says. "The small male and large female *A. africanus* skulls we studied differ comparably in size to a small male Bushman and a large female Zulu of today."


Loth

Frontal view of Mr. Ples (left) and a female of his species shows their zygomatic arches.

Unless pelvic remains turn up — a rare occurrence — the sex designation of a fossil skull or jaw hinges on a comparison of bone size and thickness among other examples of the same species.

Loth's group looks for sex-specific facial traits. One such marker is the shape of the zygomatic arch, a narrow bone that runs horizontally on each side of the face from just below the eye to just above the ear.

When viewed from the rear, the zygomatic arch of male primates typically rises sharply near the ear and juts back into the skull, creating a trapezoidal shape, Loth contends. In females, the zygomatic arch gently curves into the skull, producing a triangular shape.

This feature correctly signaled sex in 168 out of 200 adult modern human skulls, 23 of 23 adult baboon skulls, and 68 of 73 adult chimpanzee and gorilla skulls, Loth says.

Zygomatic arch analysis has also identified an *A. boisei* skull as male and a *Homo erectus* skull as female. Both fossils come from East Africa.

Previous research directed by Loth found that, in modern humans, the lower jawbone angles sharply toward the rear of the skull as it ascends to the cheek in nearly all males, but it remains relatively straight in females.

Hormonally regulated growth of chewing muscles and their associated bones create sex-typical facial traits such as these, Loth asserts.

"I think Loth has discovered something very important," remarks Milford H. Wolpoff of the University of Michigan in Ann Arbor.

The new technique may offer insights into the debate over whether *A. afarensis,* which includes the famed fossil Lucy, consisted of large males and small females or actually comprised two separate species, Wolpoff notes. *— B. Bower*