Stone blades yield early cultivation clues

Scientists have long speculated about the uses of stone-bladed sickles found at prehistoric sites in the Middle East. Microscopic analysis of polish and wear on a large sample of the stone blades now indicates they were used to harvest cereals for food between 12,000 and 6,000 years ago, according to a report in the February Current Anthropology.

"It also appears some kind of small-scale cultivation of cereals involving digging in the soil took place 12,000 years ago," says archaeologist Romana Unger-Hamilton of University College in London, England.

If the latter conclusion holds true, a 3,000-year span separated early cultivation efforts and the appearance of full-scale agriculture in the same region. This supports other recent evidence that agriculture originated in a step-by-step process, not a sudden revolution.

Unger-Hamilton's first step was to produce 295 experimental blades from a variety of stone, including material from near the archaeological sites. The blades were used, either bare-handed or attached to copies of bone and wooden handles discovered with the prehistoric blades, to harvest 17 wild and 12 cultivated plant species, as well as 5 types of weeds growing among the plants. Harvesting was done as close as possible to archaeological sites.

A polish develops on the blades with continued cutting of plants, Unger-Hamilton says. When viewed under a microscope, polish distribution clearly differs among the three plant groups studied; in most cases, it differs from one plant species to another. Blade polish variations also indicate whether a plant was cut under the seed or near the base, whether it was green or ripe, wet or dry at the time of cutting, whether the blades were attached to a handle and whether the handle was curved or straight.

When plants are cut close to the ground, and the soil is loose, striations or grooves appear in the blades, Unger-Hamilton adds.

Her next step was to study the polish on 761 flint sickle-blades collected at prehistoric sites in present-day Israel. Some blades date back to the Natufian culture, which existed between 12,000 and 10,000 years ago. Others came from Neolithic, or New Stone Age, locations dating to between 10,000 and 8,000 years ago.

About 80 percent of the blades had a polish distribution similar to experimental cereal polishes, Unger-Hamilton says. The overall pattern suggests most blades were attached to curved sickles, she notes.

About one-quarter of the Natufian and three-quarters of the Neolithic blades were heavily striated. The steady increase in striations over time and their consistent distribution among the early sites indicates, in Unger-Hamilton's view, the harvesting of cereals from tilled soil occurred 12,000 years ago and gradually became more commonplace.

In her harvesting work with the experimental blades, conducted in 1985 and 1987, Unger-Hamilton observed dramatic variations in the availability of wild cereals and other wild plants. Wild emmer and barley near the older archaeological sites ripen quickly and are available for harvesting for only a few days before local hot winds shatter the plants' protective ears. Plant food shortages may have provided an important incentive for cereal cultivation by early Natufians, Unger-Hamilton says.

Other factors, such as the appearance of village settlements and population pressures, may not have played crucial roles in stimulating Natufian plant cultivation, she maintains. But a warming of the climate around 12,000 years ago appears to have contributed to cereal availability and the potential for cultivation.

Unger-Hamilton's demonstration of cereal cutting by early Natufians is persuasive, says Harvard University archaeologist Ofer Bar-Yosef, but it is not clear whether they tilled the soil or harvested cereals in large natural stands. It is difficult to establish whether wild or cultivated plants were gathered, he notes, since soils in that region do not contain many fossilized plant remains.

About 50 years ago, Bar-Yosef says, archaeologists first suggested the sickle-blades were used to cut edible plants.

Bar-Yosef asserts an abrupt climatic warming, combined with increasing populations in areas where resources had not been overexploited, sparked early Natufian plant cultivation. *— B. Bower*

Semiconductor devices transfer like decals

Lots of kids master the childhood technology known by some as Silly Putty transfer. By pressing Silly Putty on a newspaper comic, kids lift off ink images and transfer them to, say, the kitchen table. Now scientists report using a related method for transferring ultrathin semiconductor devices from one place to another. Faster computers, new opto-electronic devices and cheaper solar cells are some of the expected payoffs, the researchers say.

Compared to silicon, the newer semiconductor material gallium arsenide makes for faster transistors. And unlike silicon, its crystals can turn laser light into electronic signals or vice versa. But because the two materials clash crystally, gallium arsenide resists growing on silicon to make hybrid opto-electronic devices.

The new material-saving technique called epitaxial liftoff may solve these problems, say researchers at Bell Communications Research (Bellcore), in Red Bank, N.J. "This will hasten the day when the world of optical fiber communications comes all the way into homes," predicts physicist Eli Yablonovitch, leader of the research team. In the February Photonics Technology Letters, the researchers report using the technique for transferring preformed thin film lasers onto glass from a gallium arsenide template, or substrate, on which they are grown.

Making gallium arsenide devices involves wafers about 0.5 mm thick, yet only the very top microns (0.001 mm) participate in the devices' actions, he says. "Well over 90 percent of the semiconductor chip is just there to mechanically support the active layer, which is incredibly thin," says Yablonovitch. "By separating the part that does the work from the part that supports it, we overcome a lot of problems." These include the substrate's inability to combine with other materials such as silicon and its poor thermal conductivity, which limits its uses to those that don't produce much heat.

Starting with a thick gallium arsenide growth substrate, the researchers successively deposit thin layers of semi- and less-conductive materials to construct devices such as transistors and lasers. First, directly on the substrate, the researchers lay down a roughly seven-atom-deep dissolvable film of aluminum arsenide. Next comes the thin laser assembly: A layer of semiconductive gallium arsenide underlies four more layers that alternate between less-conductive gallium aluminum arsenide and gallium arsenide. The middle gallium arsenide layer responds to electronic currents between the uppermost and bottommost layers of the material by emitting laser light. A layer of mechanically supportive wax tops it all off.

Treatment with hydrofluoric acid, which eats through the aluminum arsenide separation layer while leaving everything else unscathed, frees the thin-layer laser from the now reusable substrate. The laser is then easily transferred to any smooth surface such as glass or polished silicon, Yablonovitch says. Once it's there, a solvent washes away the wax.

Using epitaxial liftoff to make hybrid devices that combine silicon-based chips with the optical capabilities of gallium arsenide is "the hope of the future," comments Paul S. Peercy, manager of compound semiconductor and device research at Sandia National Laboratories in Albuquerque, N.M. *— I. Amato*