pace within-group differences," Harpending holds. But this pattern of change in the structure of mitochondrial DNA does not characterize his computer models of single populations that rapidly grow and split into separate clusters. "Groups of archaic humans apparently remained isolated from each other for tens of thousands of years," Harpending says.

The dating of humanity's common mitochondrial ancestor does not show that our species suddenly evolved around 200,000 years ago, Harpending says. The mitochondrial DNA evidence simply cannot illuminate the structure of human populations before that time, he asserts. But his group estimates that the number of human females at the time mitochondrial Eve lived ranged from 1,000 to no more than 10,000.

This relatively small population shows genetic signs of slight size expansion in Africa around 100,000 years ago, with major size increases occurring on that continent approximately 80,000 years ago, the researchers maintain. Population growth blossomed in Asia and Europe about 50,000 to 40,000 years ago, according to the mitochondrial DNA comparisons.

Up until these growth spurts, stone tools and other artifacts found at sites throughout Eurasia displayed many similarities; soon thereafter, sophisticated regional cultures appeared, Harpending and his co-workers note. Indeed, cultural change may have sparked marked population increases in dispersed human groups, they argue.

Alan R. Templeton, an evolutionary biologist at Washington University in St. Louis, regards the new analysis of mitochondrial DNA with considerable skepticism. He provided the statistical critique that chopped down earlier evolutionary trees derived from mitochondrial DNA.

"This study is a step in the right direction," Templeton remarks. "But the computer models of population expansion are pretty simple and only test the Out of Africa theory, not multiregional evolution."

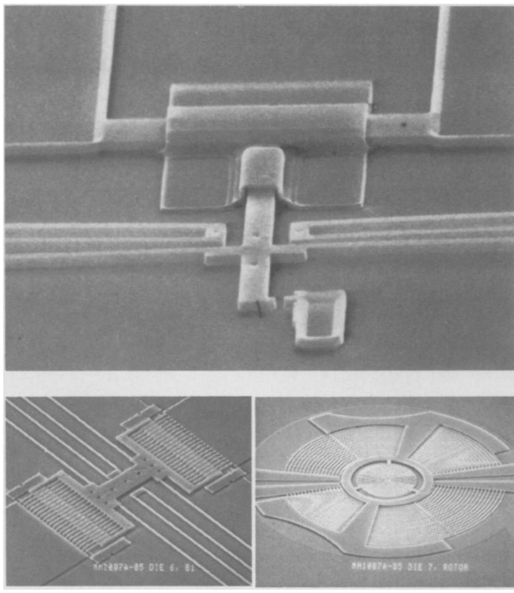
Harpending acknowledges that large margins of error exist in his simulations: "We all feel that we need to move beyond mitochondrial DNA as a locus of study."

In a report in the March AMERICAN ANTHROPOLOGIST, Templeton found no evidence for a definite geographic origin for a common mitochondrial ancestor, whom he dates to around 800,000 years ago. Current mitochondrial DNA variations come from dispersed, ancient populations, he contends.

Using a computer program that analyzes the geographic distribution of DNA differences, Templeton concluded that humans experienced size expansions largely within continents, with periodic contact across continents.

– B. Bower

Micro steam engine makes forceful debut



Sniegowski/Sandia National Labs

Micron-scale motors: Above, a new steam engine; below, two electrostatic motors.

For some time now, microelectronics engineers have been chugging along, struggling to build a pinhead-size engine capable of doing some real work on the tiniest scale. The goal is to hook a micromotor to some minitools and move speck-like objects around. But until recently, state-of-the-art engines just haven't had enough oomph.

Now, a new motor has come onto the scene: a steam engine small enough to sit on a computer chip, yet powerful enough to do useful work.

Invented by Jeffry J. Sniegowski, a physicist at Sandia National Laboratories in Albuquerque, and his colleagues, the engine measures all of 6 microns long and 2 microns wide. Perched on a polycrystalline silicon wafer, it sports "a single piston that slides in and out of a silicon sleeve, moved by a bubble of water vapor that expands and contracts as it's heated," Sniegowski says.

What distinguishes this engine from the more common types of micromotors – called electrostatic comb devices – is its strength. It can deliver up to 100 times more power than the electrostatic motors, with a peak force of roughly half a micronewton. Unlike electrostatic actuators – which use electrical charge rather than water vapor pressure to do their work – this steam engine could potentially open and close gates and cut, move, and probe objects smaller than a single human blood cell.

"One of the biggest problems with microactuators is producing enough force to do the work you need done," says Paul McWhorter, an electrical engineer at Sandia who helped develop the steam engine. "The existing devices, mostly electrostatic comb motors, look very impressive when they're running. But they don't deliver much force, which is a problem. In some cases, the force generated is only a little more than the internal friction generated by the device itself. This [steam] engine uses a fundamentally different type of actuation."

Sniegowski originally developed the steam engine to move an optical sensor inside a nuclear weapon, but he is now looking for more general civilian applications. "We want to build a set of microtools, which means coupling this steam engine to small tweezers, scalpels, probes, or sensors. Since it generates enough force to do work, the question is, what useful work should it do?"

Possibilities include microsurgery or any other delicate operation that requires sensitively positioning objects as small as a single cell. "Eye surgery, neurosurgery, certain areas of brain surgery come to mind," says McWhorter. "Right now we're looking for neurosurgeons and eye surgeons to tell us what they really need."

Other potential applications include use in fiber optics, lasers, electron microscopy, and semiconductor manufacturing – "basically, any area of science or medicine where very precise alignment is a critical factor," says McWhorter. Even sensors. "It turns out that these devices make excellent accelerometers and pressure sensors, which are useful for cars, boats, planes, or any vehicle that needs a navigation system. Since they can detect subtle motion changes, they may also be useful in geological research as seismic monitors."

Another advantage of the miniature steam engines is that "they're cheap to make," says McWhorter. "You can fabricate them in a facility for making high-density electronic memories for less than $10 apiece. For about $50,000 you can produce 20 wafers, each with 1,000 steam engines on it. When you figure in production costs and throw away the engines that don't work, the end price would be between $5 and $10 apiece. And, of course, as the volume rises, the price falls. This is a much simpler structure to build than a computer chip."

Both Sniegowski and McWhorter say they have entertained some far-off applications as well.

"People have talked to us about powering microrobots, microrefrigeration systems for computer chips, devices that float in a person's bloodstream," says McWhorter. "But for now, the next step is to build the microtool kit by coupling the engine to pumps, valves, and tweezers."

– R. Lipkin