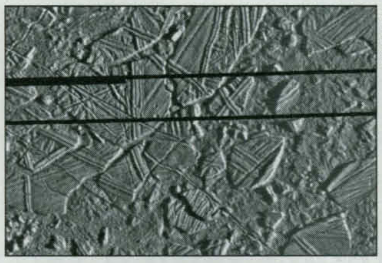
PLANETARY SCIENCE

An Ocean Emerges on Europa

Hints of ancient life on Mars have captivated planetary scientists since last summer, but last week their attention jumped to Jupiter's moon, Europa, when researchers announced what they consider persuasive evidence of a deep ocean below Europa's icy surface. Images newly returned by the Galileo spacecraft show a complex, shattered terrain that bears an eerie resemblance to the ice cover of the Arctic Ocean, researchers said at a NASA press conference in Pasadena, California. If Europa does harbor an ocean, the planet would have an abundance of liquid water—a key prerequisite for life. Some members of the Galileo team, however, aren't ready to take the plunge.

When Galileo began returning images of Europa late last year, planetary scientists realized that something has been disrupting much of the moon's surface by squeezing up ridges and crumpling some areas into thoroughly chaotic terrain. Last month, at the Lunar and Planetary Science Conference in Houston, team member Clark Chapman of the Southwest Research Institute in Boulder, Colorado, argued that the striking dearth of meteorite craters on some parts of Europa implies that the surface is still being reshaped.

Now, the latest Galileo images have convinced some researchers that a thin layer of ice floating on liquid water is the most reasonable way to explain this turmoil. Europan geology "does look a lot like the ice cover of the Arctic Ocean," said arctic researcher Max Coon of NorthWest Research Associates Inc., in Bellevue, Washington. Kilometers-long slabs of ice appear to have broken off and drifted in a "sea" of what looks like refrozen water. "These are icebergs," said Galileo team member Paul Geissler, of the University of Arizona. He and fellow team member Michael Carr of the U.S. Geological Survey in Menlo Park, California, argued that only the circulation of a warm ocean could have partially melted the ice crust and dragged the "icebergs" around.


JPL/NASA

Extraterrestrial icebergs? New views of Europa resemble the Arctic Ocean.

But not everyone is convinced. "It's a bold hypothesis that probably has some staying power," said team member Robert Sullivan of Arizona State University, "but there is room for some surprises." Indeed, each time Galileo has swung by Europa and gathered more images, geologists have had to toss out previous ideas about the moon's geology. In January, for example, the team suggested that "ice volcanoes" have flooded the surface with icy lavas, but Sullivan has now backed away from that idea. Team member Robert Pappalardo of Brown University remains cautious too: "I don't think we have proof of an ocean," he says. "I would argue for keeping open the option that this stuff has moved around on top of ductile ice instead of an ocean. We have a good suggestion of an ocean, but it needs testing."

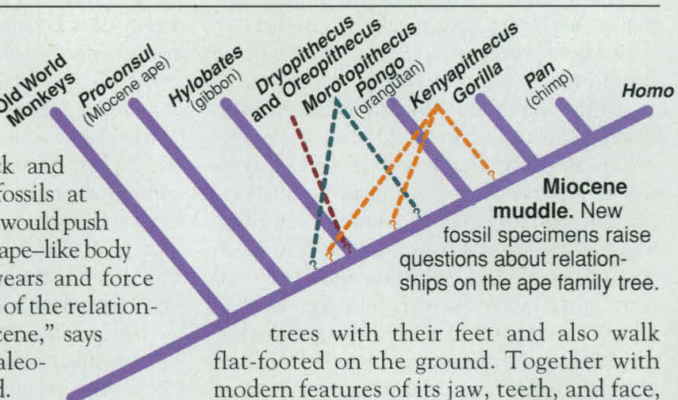
–Richard A. Kerr

PALEOANTHROPOLOGY

Miocene Primates Go Ape

Wind back the clock 5 million to 23 million years to the Miocene, and parts of Eurasia and Africa would seem like the planet of the apes. "If you could have walked from Spain to China 10 million years ago, you'd have seen an amazing diversity of apes," says University of Texas paleoanthropologist John Kappelman, who estimates that no less than 30 different types of early apes lived during the Miocene. But after this spectacular flowering, nearly all these apes became extinct, with only one lineage surviving to give rise to modern apes and humans. Although there have been plenty of candidates for this distinction, including chimpanzee-sized apes from Europe called *Oreopithecus* and *Dryopithecus*, anthropologists have had only fragmentary fossils to tell them which one.

Now, thanks to new fossil finds, two African species are seeking prime ancestral spots on the modern ape family tree. New "apelike" arm and ankle bones from one candidate, *Kenyapithecus*, indicate that this 14-million-year-old primate was "the best, most likely ancestor of humans, chimps, and gorillas," say paleoanthropologists Monte McCrossin and Brenda Benefit of Southern Illinois University. And another team has proposed a larger tree dweller called *Morotopithecus* as an even earlier ancestor. In a report on page 401, Northern Illinois University anthropologist Daniel Gebo and his colleagues identify modern features of this ape's back and shoulder, and date the fossils at 20.6 million years old. That would push the emergence of a modern ape–like body plan back by 5 million years and force researchers to "rethink all of the relationships of apes in the Miocene," says University of Missouri paleoanthropologist Carol Ward.



Miocene muddle. New fossil specimens raise questions about relationships on the ape family tree.

Kenyapithecus has been a contender for human ancestry ever since the 1960s, thanks to face bones and teeth that set it apart from other Miocene apes. But other parts of *Kenyapithecus*'s skeleton turned out to look more primitive, and it was pushed to an outlying branch of the ape family tree—outside the African ape group, which includes modern gorillas, chimps, and humans (see diagram). Now, however, McCrossin and Benefit claim that new fossils found last summer on Maboko Island in Kenya's Lake Victoria bring *Kenyapithecus* back in the African ape family.

Working with 135 excavators, they unearthed several new *Kenyapithecus* bones that they say resemble those of modern apes, including a straight upper arm bone and an ankle bone shaped to allow *Kenyapithecus* to rotate its foot sideways—a feature of living chimps that allows them to cling to trees with their feet and also walk flat-footed on the ground. Together with modern features of its jaw, teeth, and face, *Kenyapithecus* is the closest ancestor of African apes, McCrossin and Benefit proposed last week at the annual meeting of the American Association of Physical Anthropologists in St. Louis.

A different set of traits has convinced Gebo, Laura MacLatchy of the State University of New York, Stony Brook, and their colleagues that *Morotopithecus* is an even older ancestor. Vertebrae from this ape, found in Moroto, Uganda, in the early 1960s, had long tantalized researchers because they suggest that *Morotopithecus* had a stiff back—a feature critical for the occasional upright posture adopted by modern apes. But other traits in *Morotopithecus*'s teeth and face were primitive.

In 1994 and 1995, however, Gebo and MacLatchy's team found a partial shoulder bone and parts of two leg bones or femurs at Moroto. Not only did argon-argon dating show these fossils to be at least 20.6 million years old—5 million years older than had been thought—but they were unexpectedly modern. The shoulder socket, or glenoid, was round, suggesting that *Morotopithecus*'s shoulder joints were mobile, allowing this ape to hang by its arms in trees, as do living apes such as chimps and orangutans. And the lower part of the femur has modern features, says MacLatchy. "Given these traits, we think it was a sister species to living apes," she says.

The new data will likely lead to a rearrangement of where different Miocene apes sit in the primate family tree and may also change researchers' views on which traits are most reliable for determining ancestry. For example, if the large-bodied *Morotopithecus* is our close relative, then large body size is a primitive trait for all apes, contrary to existing models. What's more, some molecular clocks assume that great apes—orangs, chimps, gorillas, and humans—split off 13 million years ago, using the date from a Pakistani ape called *Sivapithecus*. The new date for *Morotopithecus* could alter those calculations, says Kappelman.

Others caution that it is too early to be redrawing family trees, noting that both claims rely mainly on skeletal traits rather than on the teeth or skull features usually used for classification. University of Toronto paleoanthropologist David Begun, for example, notes that the classification of *Morotopithecus* as a sister group to living apes depends primarily on just two skeletal bones, one of which is very fragmentary. Nor are Begun, Ward, and others convinced that the new arm bone of *Kenyapithecus* is apelike; they are waiting for a published description of the fossils. "I think we can expect continuing clouds of discomfort as to how to handle all this new material," says Kappelman. "But it's the beginning of a great research enterprise."

–Ann Gibbons and Elizabeth Culotta

SEMICONDUCTORS

Growing Crystals With a Twist

Researchers who make semiconductor crystals for computer chips and other electronics applications are notorious perfectionists—and for good reason. To give the best performance, a chip has to be nearly defect free. But growing perfect crystals is difficult because of mismatches between the atomic lattice pattern of the semiconductor and the substrate, a supporting surface that provides a template for the crystal being deposited on top. As a result, strain builds up in the growing lattice, triggering cracks in the crystal. Now, however, researchers have found a simple way to ease the strain.

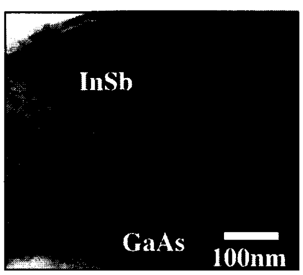
At the semiannual Materials Science Research meeting in San Francisco 2 weeks ago, a team of researchers from Cornell University in Ithaca, New York, and Sandia National Laboratory in Albuquerque, New Mexico, reported that a thin, flexible film sandwiched between the substrate and the crystal can act as a buffer. By absorbing the strain, it allows a wide variety of crystalline materials to be grown on the same substrate material virtually defect free, even when the distance between atoms in the two lattices differs by as much as 15%—a considerable mismatch by industry standards.

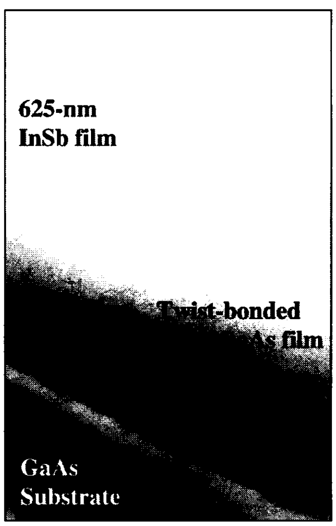
According to David Jesson, a semiconductor growth expert at Oak Ridge National Laboratory in Tennessee, the team's findings are "very interesting" because they may allow scientists to create high-quality crystals of new semiconductors. And that, says Cornell team leader Yu-Hwa Lo, could open the door to higher performance computer chips as well as new optoelectronic devices, such as more sensitive infrared detectors and chip-based lasers that beam out colors across the rainbow.

Up to now, crystal growers have been in a bind. They need substrates to organize the growth of semiconductor crystals, but standard substrates do this a little too well. Their atoms are locked into such a strong, rigid lattice that when strain builds up between the two layers, it's inevitably the more fragile, still-forming crystal that fractures. So, Lo and his colleagues decided to see if they could create a sacrificial layer that would absorb the building strain and fracture, thus sparing the growing crystal.

Their strategy was to top the substrate material with a few weakly bound layers of atoms that could move around and absorb the strain. But because any atoms deposited directly onto the substrate would be locked into the same rigid lattice, creating this weak layer required a little ingenuity. The team started with a slab of gallium arsenide (GaAs), a standard substrate crystal, coated with a layer of indium arsenide. Then, they added a film of GaAs as little as five atomic layers thick, which ultimately would serve as the flexible film. Finally, they took a second slab of GaAs and bonded it on top—but with a twist.

Instead of stacking the two slabs neatly, like playing cards in a deck, the scientists rotated the top GaAs slab so that its lattice was at a 45° angle relative to that of the substrate slab and the GaAs film, below. The researchers then used two conventional etching solutions to eat away the bottom two layers until only the ultrathin GaAs film was left attached to the second GaAs substrate. This served as the new substrate and starting material for growing high-quality crystals.





Sacrificial film. Strain builds between GaAs substrate and InSb crystal, causing fractures (*left*). But twist-bonded film sandwiched between the two layers absorbs strain, yielding a near-perfect crystal (*right*).

F. E. EJECKAM, M. L. SEAFORD, Y. H. LO/CORNELL UNIVERSITY AND H. Q. HOU AND B. E. HAMMONS/SANDIA LABS

When the researchers tested their new substrate by growing new semiconductor compounds on top, such as one made from indium antimonide (InSb), the difference was readily apparent. InSb films grown on conventional substrates are normally riddled with as many as 10 billion defects per square centimeter. But on the flexible substrate, the defects were reduced over 1 millionfold to an undetectable level.

Lo explains that bonding the GaAs slab and ultrathin film together at an angle "dramatically changes the property of the [film]" by preventing the thin film's atoms from forming rigid covalent bonds with the bulk GaAs substrate. "That allows the atoms [in the thin layer] to move," absorbing strain, he says.

This ability to turn out relatively defect-free semiconducting crystals could speed up the commercialization of blue lasers using semiconductor chips made from gallium nitride (GaN), says Lo. Because there is no cheap substrate with a lattice closely matched to GaN, lasermakers end up with GaN films containing billions of defects, which can trap heat and cause the devices to burn out rapidly. The Cornell researchers have yet to show that their technique can be used to build better GaN lasers or other working devices, but Lo says they are already gearing up to do just that. If the technique works, it will undoubtedly inspire other semiconductor researchers to search for a little more perfection of their own.

–Robert F. Service