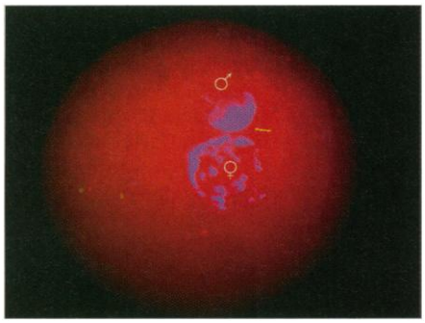
and perhaps find other clock-controlled behaviors as well, says Rob Jackson of Tufts University College of Medicine in Boston. Indeed, even though it is not yet certain that PDF really is the clock's output signal, the flurry of speculation about its possible roles has begun. –MARCIA BARINAGA

HUMAN GENETICS

mtDNA Shows Signs of Paternal Influence

Women have struggled to gain equality in society, but biologists have long thought that females wield absolute power in a sphere far from the public eye: in the mitochondria, cellular organelles whose DNA is thought to pass intact from mother to child with no paternal influence. On page 2524, however, a study by



Mighty mitochondria. Human sperm mitochondria (yellow line) can gain entry to eggs.

Philip Awadalla of the University of Edinburgh and Adam Eyre-Walker and John Maynard Smith of the University of Sussex in Brighton, U.K., finds signs of mixing between maternal and paternal mitochondrial DNA (mtDNA) in humans and chimpanzees. Because biologists have used mtDNA as a tool to trace human ancestry and relationships, the finding has implications for everything from the identification of bodies to the existence of a "mitochondrial Eve" 200,000 years ago.

The study "is pretty compelling and I can't think of good alternative explanations," says Richard Hudson, a population geneticist at the University of Chicago. Anthropologists agree that if the study holds up, it could trigger a major shake-up in their field. "There is a cottage industry of making gene trees in anthropology and then interpreting them," says Henry Harpending, an anthropologist at the University of Utah, Salt Lake City. "This paper will invalidate most of that."

Yet not everyone is ready to grant a role to fathers in mtDNA inheritance just yet. Hudson and others caution that the new result "changes our view dramatically enough that we have to continue to think of other ways to explain it." Fathers contributing mtDNA to their offspring "implies several different novel and important biological phenomena that no one's ever seen before," such as contact between maternal and paternal mtDNA, adds Neil Risch, a human geneticist at Stanford University School of Medicine.

Researchers have assumed that mtDNA passes only through the mother, in part because experiments have shown that eggs destroy sperm after fertilization, and that mitochondrial traits, including a variety of inherited disorders, seem to come only from mothers. But some mtDNA sequences didn't fit neatly into a tree of maternal descent (*Science*, 5 March, p. 1435), so the scientists decided to look for signs of mixing between paternal and maternal mtDNA.

Such mixing—the usual fate of DNA in the cell nucleus—is called recombination, and it takes place when a piece of a DNA strand from one parent crosses over and pairs up with a strand from the other parent. The process generates a novel DNA molecule with features donated by each parent.

To probe whether recombination occurs in the mitochondrial genome, the team analyzed DNA variations. DNA in different individuals varies at many positions, so each new mutation arises on a distinctive genetic background. Unless the DNA can reshuffle itself, the new mutation will stick with the variations already on the same chromosome as it is passed on. But recombination, which mixes up pieces of the DNA, should gradually destroy such nonrandom linkages between DNA variations. The farther apart two sites lie on the chromosomes, the faster recombination can eliminate the linkage. Thus, if recombination is operating, specific variations are less likely to be found together if they are far apart on the chromosome than if they are neighbors.

Using mtDNA from humans and chimpanzees, the researchers tallied how often specific mutations at different sites tended to occur together; they also noted the distance between the mutation sites. In four out of five human data sets and one chimp set, nonrandom mutations at distant sites were less likely to be linked than nearby mutations—implying recombination between maternal and paternal DNA, says Eyre-Walker.

Such recombination could be a blow for researchers who have used mtDNA to trace human evolutionary history and migrations. They have assumed that the mtDNA descends only through the mother, so they could draw a single evolutionary tree of maternal descent—all the way back to an African "mitochondrial Eve," for example. But "with recombination there is no single tree," notes Harpending. Instead, different parts of the molecule have different histories. Thus, "there's not one woman to whom we can trace our mitochondria," says Eyre-Walker.

What's more, over time, recombination mixes up genomes so that they become more homogeneous. That "makes even distantly related people look more similar to each other," says Eyre-Walker, and causes past events to seem more recent than they really are. Our last common female ancestor, for example, would be older than the mtDNA implies. But not every mtDNA study would be invalidated by recombination, Eyre-Walker notes. "The major impact will be on the timing of those events and our basic understanding of mtDNA evolution," he says.

Even so, many researchers aren't ready to accept these data as ironclad evidence of recombination. Other genetic processes might create a similar pattern, says evolutionary biologist Rebecca Cann of the University of Hawaii, Manoa. Some researchers have proposed models in which one mutation is more likely to occur close to another. "It's not yet clear whether there aren't explanations other than recombination," agrees Vincent Macaulay, a mathematical geneticist at the University of Oxford.

Skeptics and supporters alike note that how recombination could be happening remains a mystery. Recombination requires physical contact between egg and sperm mtDNA, for example, and it's not clear when or how these molecules touch. In any case, it's possible to square previous observations of mtDNA inheritance with "a little bit of paternal leakage," adds Jody Hey, an evolutionary geneticist at Rutgers University in Piscataway, New Jersey. Just how much leakage might take place is a critical question in practical as well as research uses of mtDNA, such as identifying human remains. "If the sequences are identical, the chances are very good that that's the woman's son or daughter," says Eyre-Walker. "If you get a one-base-pair mismatch, do you say 'This is not your child?'" –EVELYN STRAUSS

PLANETARY SCIENCE

Galileo Catches Lava Fountain on Io

SAN FRANCISCO—Astronomers are galvanized by a new image of what may be a curtain of lava spewing above a volcano on Jupiter's moon Io. The picture, snapped by the Galileo spacecraft during its daredevil dive past Io on Thanksgiving and released last week at a meeting of the American Geophysical Union, also reveals a complex, jagged cliff arcing near the volcano—further evidence of the moon's geologic turmoil.

Planetary scientists have long known that Io is the most volcanically active body in the solar system, thanks to constant gravitational tugs from Jupiter and its other moons that churn Io's interior. Galileo had previously revealed surface flows within vast volcanic

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