A New Face for Human Ancestors

An 800,000-year-old species from Spain takes its place on the human family tree, and these first Europeans may be ancestral to both modern humans and Neandertals

More than 780,000 years ago, a boy with a remarkably modern face lived near a warren of caves in the red limestone Atapuerca hills of northern Spain. He died young, possibly the victim of cannibalism, and today only part of his face remains. But that part is stunning, because despite its antiquity, it "is exactly like ours," says paleoanthropologist Antonio Rosas of the National Museum of Natural Sciences in Madrid, Spain. On page 1392, Rosas and his colleagues, who found the remains of the boy and five other early humans in a railway cut, suggest that these people—the oldest known Europeans—were members of a new species of early humans directly ancestral to us.

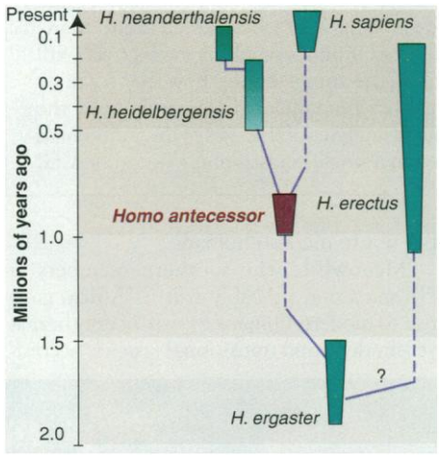
The Spanish team has named this first new member of the human family in over a decade *Homo antecessor*, from the Latin word meaning explorer or one who goes first. They say that the species's unusual mix of traits—in particular, the boy's modern face set between a primitive jaw and brow—shows that it gave rise to both modern humans and Neandertals, the heavyset species that lived in Ice Age Europe until about 28,000 years ago.

Other paleoanthropologists are impressed by the finds—more than 80 fossils, including skulls, jaws, teeth, and other parts of the skeleton—that offer new insight into a mysterious time and place in human evolution. "We now have a better window on the first peopling of the European continent," says paleoanthropologist Philip Rightmire of the State University of New York (SUNY), Binghamton. But identifying these people as a new species, not to mention claiming them as a key human ancestor, is highly controversial. "I think many of my colleagues will be uncomfortable with creating a new species, because it is mainly based on the facial features of one juvenile," says paleoanthropologist Jean-Jacques Hublin of the National Center for Scientific Research (CNRS) in Paris. What's more, if *H. antecessor* is indeed the last common ancestor of Neandertals and modern humans, it could bump two other favored contenders—*H. erectus* and *H. heidelbergensis*—off the main line of descent leading to modern humans, making them side limbs on an increasingly bushy human family tree.

That's too drastic a revision for many researchers to swallow. Some, however, think the new family tree with all its offshoots helps explain an increasingly diverse fossil record. "It's further evidence for the complexity that we're finding all the way down the story of the evolution of *Homo*," says Chris Stringer, a paleoanthropologist at the Natural History Museum, London.

Seeing a familiar face

Only a decade ago, the textbook view of the evolution of *Homo* was that of a gradual, straightforward progression, with one species unfolding into another—a pattern quite different from the diversity seen in other animals. First came *H. habilis*, the toolmaker, arising more than 2 million years ago from apelike australopithecines. Then came *H. erectus*, the upright walker who trekked across Africa and Asia about 1.8 million years ago. It gave rise in the past 500,000 years to a relatively robust ancestor called archaic *H. sapiens*, which led to both our species and Neandertals.



J. BERMÚDEZ DE CASTRO AND J. L. ARSUAGA

A new relative. *Homo antecessor* claims a key spot on the human family tree.

But in the past decade, new fossils and reanalysis of old ones have prompted researchers to rewrite this script and add more characters, including several different types of early *Homo* in Africa (*Science*, 22 November 1996, p. 1298). And they also have changed the cast in the final acts. Notably, half-million-year-old African and European fossils once described as archaic *H. sapiens* now are attributed to the species *H. heidelbergensis*, which many think was ancestral to Neandertals and modern humans.

This view has been hard to test, however, because of huge gaps at critical times in the fossil record of Europe. From the time the first humans left Africa about 1.8 million years ago until some 500,000 years ago, not a single bone had been found in Europe. Then, in 1994, new excavations in Spain uncovered fragments of hominid bones and teeth at a site called Gran Dolina, where railroad workers blasting through Atapuerca Hill in the 19th century had exposed cross sections of bone-filled limestone caverns. The layers containing human fossils were dated using periodic shifts in Earth's magnetic field to more than 780,000 years old (*Science*, 11 August 1995, pp. 754, 826, and 830). That makes these "exciting because they are the earliest well-dated fossils from Europe," says University of Michigan paleoanthropologist Milford Wolpoff.

Subsequent field seasons yielded simple stone tools and more fossils from at least six individuals. And as soon as the Spanish scientists cleaned up the fossils—particularly the face of the boy—they knew they had found something special. The face had familiar modern features, such as sunken cheekbones with a horizontal rather than vertical ridge where the upper teeth attach, and a projecting nose and midface. "We realized right away it was modern looking," says paleoanthropologist Juan Luis Arsuaga of the Universidad Complutense in Madrid, co-leader of the team with paleoanthropologist José Bermúdez de Castro of the National Museum of Natural Sciences, Madrid, and archaeologist Eudald Carbonell of the University of Tarragona.

But the fossils also had primitive features, such as a prominent brow ridge and multiple roots for premolars. It all added up to an unusual mosaic of modern and primitive features that just didn't fit any known species. "We tried to put them in *H. heidelbergensis*, but they were so different that we could not," says Arsuaga. And so they set the fossils apart as a new species.

Next, the team tried to solve the problem of where *H. antecessor* sits in the human family tree. And here the researchers go out on a limb, relying on a few dental and cranial features to suggest that *H. antecessor* is close kin to 1.6-million-year-old fossils from East Africa, which some researchers identify as *H. ergaster*. This species resembles *H. erectus*—indeed, some consider it part of *H. erectus*—but others have proposed that only the African *H. ergaster* is ancestral to modern humans, while the Asian *H. erectus* went down a different evolutionary path. The Spanish team supports this view by noting traits that link *H. antecessor* to *H. ergaster*

Into the Pit of Human History

In 1976, Spanish paleontologist Trinidad Torres was searching for bear fossils in well-known beds at Atapuerca, near the city of Burgos in northern Spain, and found a human bone instead. This search had uncovered what turned out to be the world's largest known repository of fossil humans from the period 780,000 to 127,000 years ago, the Middle Pleistocene. The locality's importance for human prehistory became clear in the early 1990s, after additional excavation at one particular site, a 14-meter shaft inside a cave known as Sima de los Huesos (Cave of Bones).

Inside this pit, researchers have found at least 32 individuals who lived 300,000 years ago. In a special 300-page issue of the *Journal of Human Evolution*, to be published in August, the Spanish team suggests that these skeletons are from a species called *Homo heidelbergensis*—a group that many paleoanthropologists regard as ancestral to both Neandertals and modern humans. Much older fossils from another part of Atapuerca, however, may have bumped *H. heidelbergensis* off the line to modern humans, says team co-leader Juan Luis Arsuaga of the Universidad Complutense in Madrid (see main text).

The fossils in the pit present a mystery. They come mainly from male and female teenagers and young adults, who were generally in good health when they died, although one remarkably complete skull is scarred with osteitis, a bone inflammatory disease, and another is from a person who apparently was deaf. What—or who—killed them? Many bones show evidence of chewing by carnivores, but animals would not selectively kill young adults and no other prey are in the pit. And the animal bones show that it's not a burial site, although Arsuaga speculates that other humans might have dumped the remains there. Researchers are now doing detailed analyses of the ages of the individuals at death, to see if they can tell whether all died in a single catastrophe. **–A.G.**

and other traits that separate it from *H. erectus*. That would bump *H. erectus*—or at least the Asian form—off the direct line to modern humans, making it a separate lineage that went extinct without descendants.

At the same time, *H. antecessor* shows enough similarities to fossils identified as *H. heidelbergensis* to be an ancestor of that species, which most paleoanthropologists agree led to Neandertals. Yet *H. antecessor* also shares more traits with modern humans than do European *H. heidelbergensis* fossils. The Spanish team therefore argues that *H. antecessor* is a key central player that ultimately gave rise to modern humans and to Neandertals—thus deposing *H. heidelbergensis* from its position as the last common ancestor of both (see family tree). The new species's midface traits are "exactly the morphology we would imagine in the common ancestor of modern humans and Neandertals, if we were to close our eyes," says Rosas.

To make sense of these clues, the Spanish team proposes that *H. ergaster* gave rise to *H. antecessor*, probably in Africa, although the new species has only been found at Atapuerca. They speculate that members of *H. antecessor* began to spread out about 1 million years ago and eventually headed north to Europe, leaving the 800,000-year-old fossils found at Atapuerca. As time passed, some members of the species evolved into *H. heidelbergensis* (and may have left the 300,000-year-old fossils at Atapuerca; see sidebar). These humans headed farther north into Europe, where they in turn led to Neandertals—but not to modern humans.

Meanwhile, the southern members of *H. antecessor*, probably still in Africa, gave rise to modern humans by way of another, as yet unidentified transitional species, according to the Spanish team's view. This middle player may include fossils already discovered in Africa that look ancestral to modern humans and are now attributed to *H. heidelbergensis*. These include a massive skull from Bodo, Ethiopia, dated to 600,000 years, and a more recent cranium from Kabwe, Zambia.

Bone cache. Researchers have found teeth and skull and limb bones of *Homo antecessor*.

Face-off

That scenario is speculative, however, and not everyone welcomes the entrance of the new species—and its retinue of still-unknown relatives. "Given the evidence presented here, I'm reluctant to endorse a new species," says SUNY's Rightmire. Otherwise, "you end up littering the taxonomic landscape with all sorts of names that may turn out to be less useful later on." Most troublesome to Rightmire, CNRS's Hublin, London's Stringer, and Michigan's Wolpoff is that the designation of the new species rests primarily on the modern features found in the boy's face. They worry that some of those features are juvenile traits that weren't present in adults, and perhaps were also found in the young of other species. More comparison of the boy's face with Atapuercan adults and juveniles of other species is needed, they say.

Rosas responds that fragmentary facial bones from Atapuercan adults do show some of the modern-looking features found in the boy's face, such as hollowed cheekbones. And the Nariokotome boy who lived 1.6 million years ago in Kenya and is often identified as *H. ergaster* does not share these modern traits. Nor do the faces of 300,000-year-old *H. heidelbergensis* youths from the younger beds at Atapuerca. "We think we have enough information to define it in the proper sense of a new species," says Rosas. "But people are probably going to need some time to accommodate this proposal."

It may take more than just time, however, to convince other paleoanthropologists that *H. erectus* and *H. heidelbergensis* are not on the line to modern humans. For one, researchers such as Rightmire think fossils designated as *H. ergaster* in Africa are really *H. erectus*—and so are ancestral to modern humans in almost any scenario. But even if *H. ergaster* is considered a distinct species, says Rightmire, its link to *H. antecessor* rests on thin evidence—"the morphology of the root system of premolars, and that's just one trait," he says. Nor does Rightmire think *H. heidelbergensis* should be removed from our ancestral lineage, because he believes it includes the Bodo skull and other recent African fossils that have ties to modern humans. "I'm going to stick to my guns and support *H. heidelbergensis* [not the new species] as the antecedent to Neandertals and recent humans."

On the other hand, others find the new order a pleasing solution to the fact that *H. heidelbergensis* is something of a "wastebasket taxa" that includes widely varying African and European fossils, as Leslie Aiello, a paleoanthropologist at University College, London, describes it. Reserving the name *H. heidelbergensis* for the European fossils and considering African fossils to be the as yet unnamed descendants of *H. antecessor* "make

things nice and neat," she says.

Regardless of where the new fossils fit in the family tree, Wolpoff and others hope the site will eventually reveal what kind of technology or behavior allowed these early humans to persist in the hostile European climate before 500,000 years ago. So far, it's hard to tell, because the tool kit found with them included only simple cutting flakes, not the more sophisticated tools found elsewhere at this time. One additional, bizarre clue is that the bones were covered with cut marks, indicating that their bodies were defleshed and processed like those of animals killed for meat (*Science*, 19 January 1996, p. 277). Bermúdez de Castro and his colleagues have suggested that this could be cannibalism, but researchers such as Peter Andrews of the Natural History Museum, London, warn that cut marks alone don't prove cannibalism.

So although the fossils give paleoanthropologists a new view of an obscure time in history, they also raise a whole crop of new questions. "That's the main contribution of the Atapuerca fossils," says Hublin. "They give us an idea of the amazing variation in *Homo*." And that diversity, notes Arsuaga, shows "that human evolution is like that of other groups. We're not so different."

–Ann Gibbons

PLANETARY SCIENCE

Spots Confirmed, Tiny Comets Spurned

Lou Frank isn't the only one seeing spots anymore. More than 10 years ago, the University of Iowa space physicist proposed that house-sized comets are pummeling Earth 20 times a minute. Frank estimated that since the planet formed, these tiny comets have dumped enough water into the upper atmosphere to fill the world's oceans.

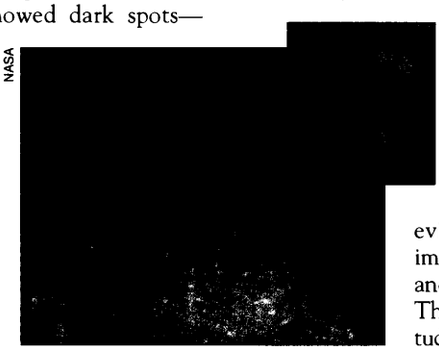
It was a provocative hypothesis from a highly regarded researcher, but the whole idea drew scorn from the rest of the earth and planetary science community. Researchers couldn't imagine where all that water could be hiding in the inner solar system, which in all other measurements seems pervasively dry. And only Frank could see the traces of these tiny objects: The dark spots formed, he said, as gassy clouds of water dispersed in Earth's high atmosphere (*Science*, 10 June 1988, p. 1403). Other researchers looking at the same satellite images, however, saw only meaningless instrument noise.

Now, in a stunning turnabout, Frank has used a satellite camera with sharper resolution to produce more detailed images that confirm the existence of these dark spots to the satisfaction of other scientists. The new data even seem to show an influx of water. "Now, you're faced with overwhelming evidence," says Frank. "We've verified [the spots] from five different viewpoints."

Even Frank's more vocal critics agree. "He's clearly seeing something, but I don't know what," says space physicist Robert Meier of the Naval Research Laboratory (NRL) in Washington, D.C. "We're all going back to the drawing boards to figure out what's going on here."

Although Frank's observations are being vindicated, he has a long way to go toward persuading the community that these black dots are actually the remains of midget comets. "There are two quite separate questions," says atmospheric physicist Donald Hunten of the University of Arizona, another early critic. "One is, are the spots real? Okay, they're real. The next question is whether Lou's explanation is valid. No, it certainly isn't valid. It is very easy to put forward five objections to the small-comet explanation, any one of which rules it out."

Frank's new data, reported this week at the spring meeting of the American Geophysical Union, come from the Polar satellite, launched in February 1996 to study magnetic fields and charged particles over the poles. This spacecraft carries ultraviolet cameras far better than the one aboard the Dynamics Explorer satellite, which took Frank's first images in the 1980s. Images from the older ultraviolet camera showed dark spots—Frank calls them "atmospheric holes"—no larger than a single picture element or pixel. Everyone except Frank and his University of Iowa colleagues John Sigwarth and John Craven, who is now at the University of Alaska, thought the single-pixel spots were instrumental noise, like snow on an ultraviolet television. Frank and his colleagues, though, interpreted them as places where 80 tons of water had absorbed enough ultraviolet to darken the UV glow of the upper atmosphere.



NASA

Seeing spots? Lou Frank believes this Polar satellite image of a dark spot (inset) against the atmosphere's ultraviolet glow (seen here in false color) marks a gassy cloud of water, the remains of a tiny comet.

Other researchers are now accepting the reality of the spots, if not Frank's explanation, because the ultraviolet images taken by the Polar satellite have much smaller pixels, and in these views the 50-kilometer-wide spots are 10 to 20 pixels across. The odds that so many randomly darkened pixels could come together to form a spot, all researchers agree, are nil. What's more, the spots show up under different imaging conditions, bolstering the case for their existence. In some cases, Frank and Sigwarth found, the Polar ultraviolet camera caught the same spot in consecutive exposures as the spot moved across the field of view. In other images, spots appeared doubled—as they should have—because Polar wobbled enough that the same object was recorded twice in one exposure. A random dark pixel would appear only once. And one particular spot, says Frank, was caught by both his ultraviolet camera and another on Polar of a different design.

Frank also presented observations of a new phenomenon high above the atmosphere that is presumably linked to atmospheric holes: bright trails of water debris. "I just happened to be looking through the images," says Frank, "and all of a sudden saw these bright oxygen trails. We were shocked." About 10 times a day, Frank concludes, an incoming small comet between 5000 and 50,000 kilometers leaves enough water in its wake that sunlight dislodges a trail of oxygen atoms from the water. Frank's final line of evidence is visible-light images showing hydroxyl, another fragment of water. These trails appear at altitudes of 2000 to 3000 kilometers, just above where small comets are supposed to disrupt to form atmospheric holes, and the trails seem to be about as abundant as atmospheric holes, says Frank. "That's totally independent verification of the ultraviolet measurements," he says.

"It's very impressive observational work," acknowledges atmospheric physicist Thomas Donahue of the University of Michigan, "that I don't think leaves us much room for doubt. There are little somethings releasing a lot of oxygen, and they show the signature of hydroxyl in emission. It's hard to imagine what other than water" they would be. But Donahue has by no means come around to the idea that these clouds of water were left by Frank's small comets. "I still have all the problems I ever had with the amount of water involved," because no one has seen it elsewhere. He ticks off the problem areas: Venus is dry, Mars is dry, Earth's upper atmosphere is dry, and the space between the inner planets is "dry" in that it has no excess of the hydrogen that small comets would leave.

Indeed, if these midget comets exist, they