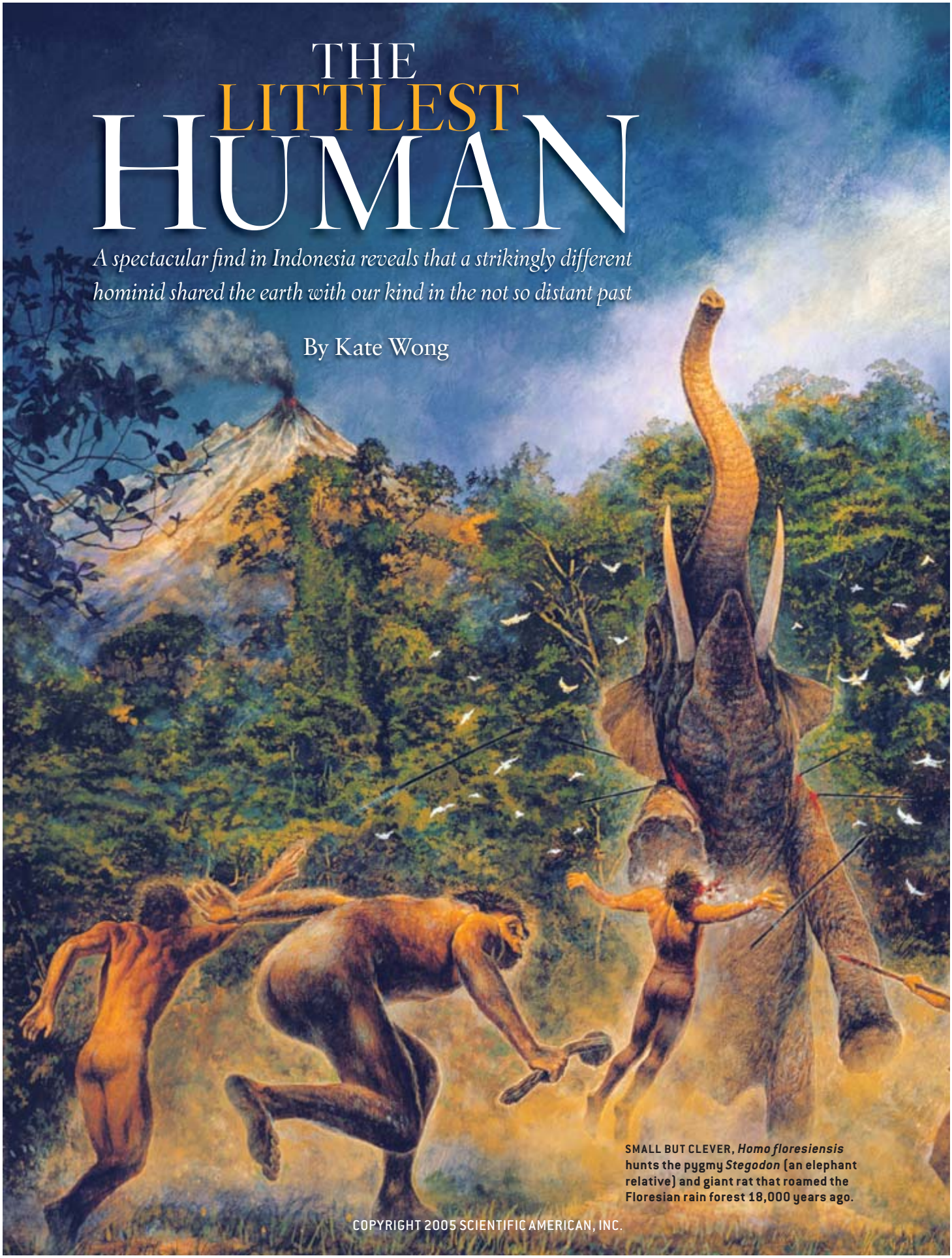
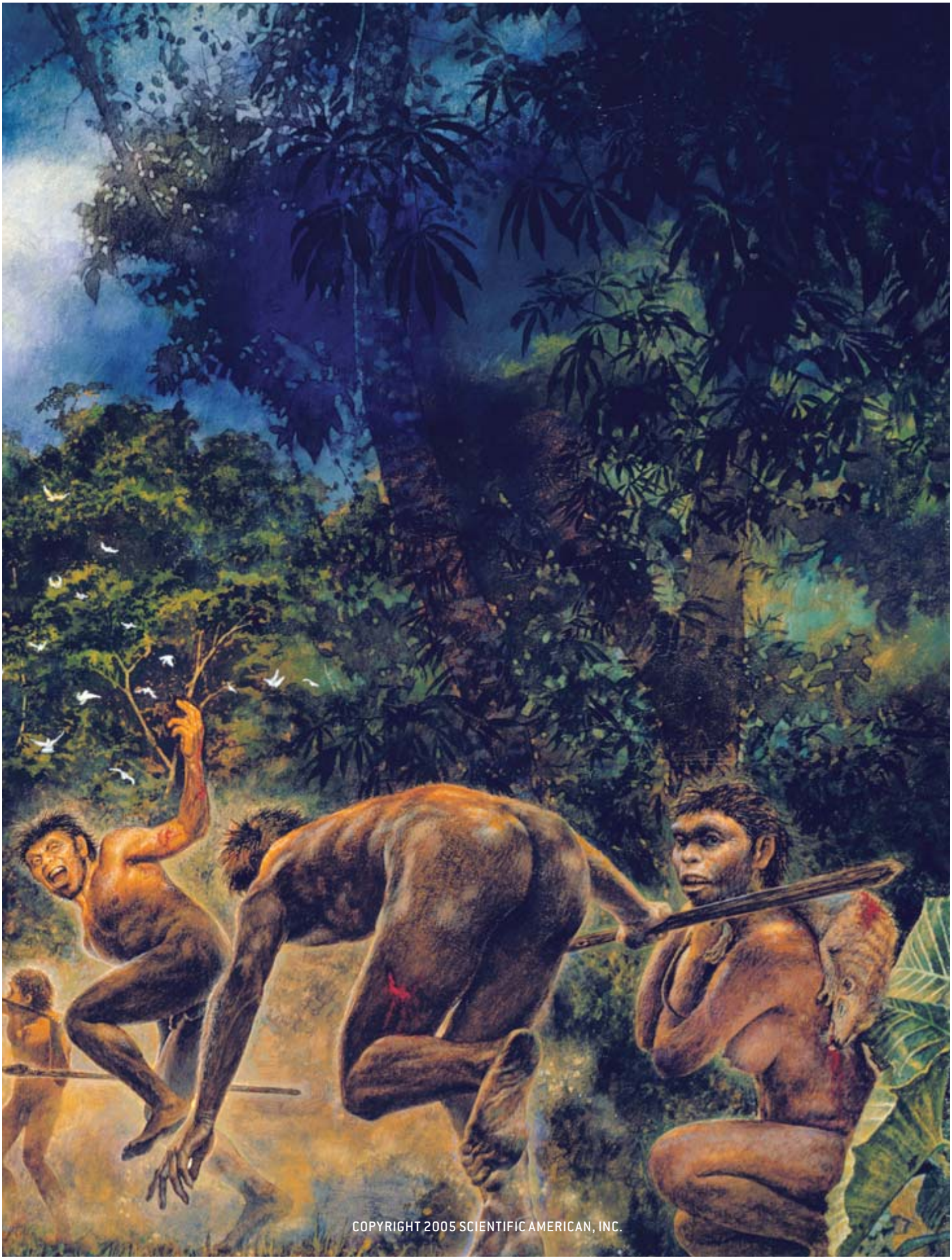
THE LITTLEST HUMAN

A spectacular find in Indonesia reveals that a strikingly different hominid shared the earth with our kind in the not so distant past

By Kate Wong



SMALL BUT CLEVER, *Homo floresiensis* hunts the pygmy *Stegodon* (an elephant relative) and giant rat that roamed the Floresian rain forest 18,000 years ago.



On the island of Flores in Indonesia, villagers have long told tales of a diminutive, upright-walking creature with a lopsided gait, a voracious appetite, and soft, murmuring speech.

They call it *ebu gogo*, "the grandmother who eats anything." Scientists' best guess was that macaque monkeys inspired the *ebu gogo* lore. But last October, an alluring alternative came to light. A team of Australian and Indonesian researchers excavating a cave on Flores unveiled the remains of a lilliputian human—one that stood barely a meter tall—whose kind lived as recently as 13,000 years ago.

The announcement electrified the paleoanthropology community. *Homo sapiens* was supposed to have had the planet to itself for the past 25 millennia, free from the company of other humans following the apparent demise of the Neandertals in Europe and *Homo erectus* in Asia. Furthermore, hominids this tiny were known only from fossils of australopithecines (Lucy and the like) that lived nearly three million years ago—long before the emergence of *H. sapiens*. No one would have predicted that our own species had a contemporary as small and primitive-looking as the little Floresian. Neither would anyone have guessed that a creature with a skull the size of a grapefruit might have possessed cognitive capabilities comparable to those of anatomically modern humans.

Isle of Intrigue

THIS IS NOT THE FIRST TIME Flores has yielded surprises. In 1998 archaeologists led by Michael J. Morwood of the University of New England in Armidale, Australia, reported having discovered crude stone artifacts some 840,000 years old in the Soa Basin of central Flores. Although no human remains turned up with the tools, the implication was that *H. erectus*, the only hominid known to have lived in Southeast Asia during that time, had crossed the deep waters separating Flores from Java. To the team, the find showed *H. erectus* to be a seafarer, which was startling because elsewhere *H. erectus* had left behind little material culture to suggest that it was anywhere near capable of making watercraft. Indeed, the earliest accepted date for boat-building was 40,000 to 60,000 years ago, when modern humans colonized Australia. (The other early fauna on Flores probably got there by swimming

KAZUHIKO SANO [*preceding pages*]

MODERN INDIAN ELEPHANT (*Elephas maximus*)

Overview/*Mini Humans*

- Conventional wisdom holds that *Homo sapiens* has been the sole human species on the earth for the past 25,000 years. Remains discovered on the Indonesian island of Flores have upended that view.
- The bones are said to belong to a dwarf species of *Homo* that lived as recently as 13,000 years ago.
- Although the hominid is as small in body and brain as the earliest humans, it appears to have made sophisticated stone tools, raising questions about the relation between brain size and intelligence.
- The find is controversial, however—some experts wonder whether the discoverers have correctly diagnosed the bones and whether anatomically modern humans might have made those advanced artifacts.

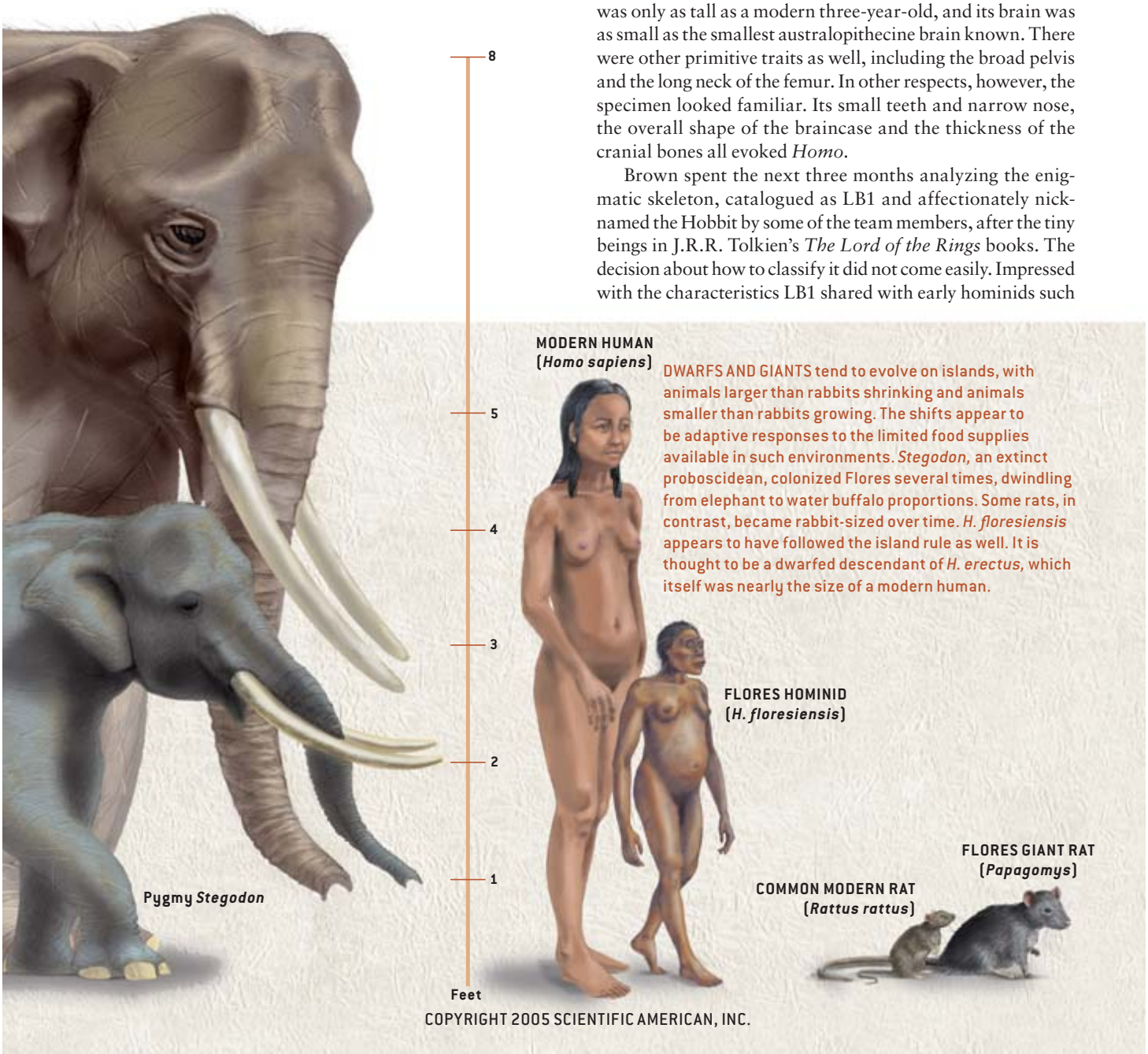
or accidentally drifting over on flotsam. Humans are not strong enough swimmers to have managed that voyage, but skeptics say they may have drifted across on natural rafts.

Hoping to document subsequent chapters of human occupation of the island, Morwood and Radien P. Soejono of the Indonesian Center for Archaeology in Jakarta turned their attention to a large limestone cave called Liang Bua located in western Flores. Indonesian archaeologists had been excavating the cave intermittently since the 1970s, depending on funding availability, but workers had penetrated only the uppermost deposits. Morwood and Soejono set their sights on reaching bedrock and began digging in July 2001. Before long, their team's efforts turned up abundant stone tools and bones of a pygmy version of an extinct elephant relative known as *Stegodon*. But it was not until nearly the end of the third season of fieldwork that diagnostic hominid material in the form of an isolated tooth surfaced. Morwood brought a cast of the tooth back to Armidale to show to his department colleague Peter Brown. "It was clear that while the premolar was broadly humanlike, it wasn't from a modern human," Brown recollects. Seven days later Morwood received word that the Indonesians had recovered a skeleton. The Australians boarded the next plane to Jakarta.

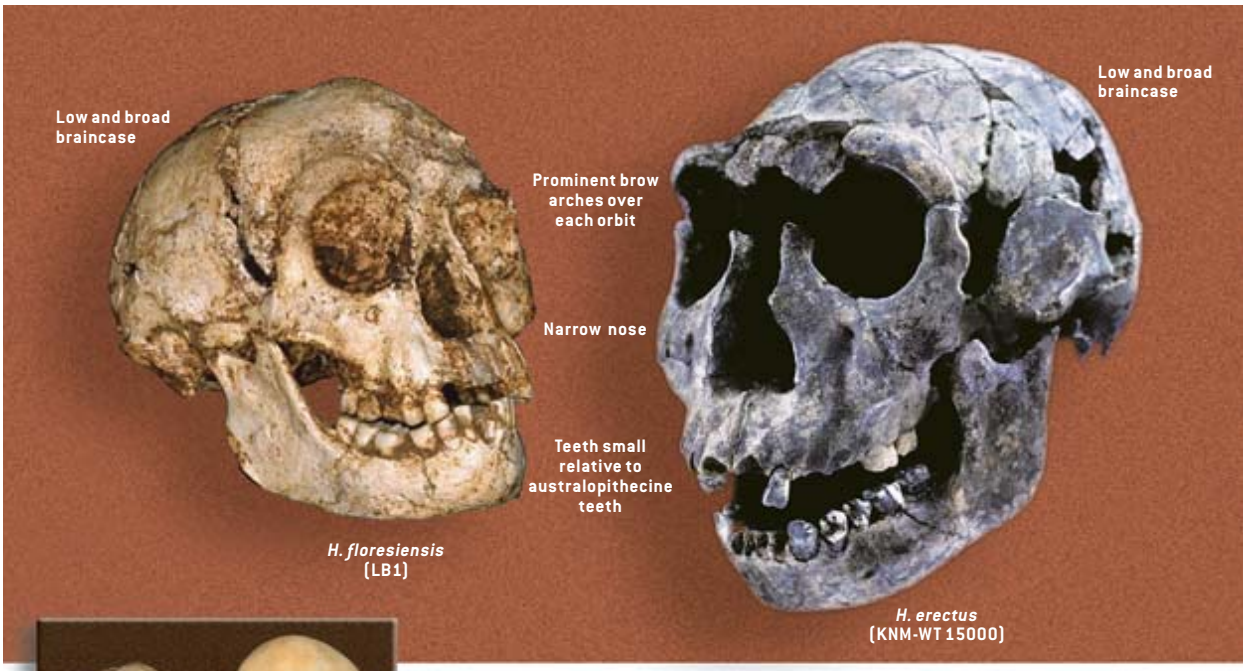
Peculiar though the premolar was, nothing could have prepared them for the skeleton, which apart from the missing arms was largely complete. The pelvis anatomy revealed that the individual was bipedal and probably a female, and the tooth eruption and wear indicated that it was an adult. Yet it was only as tall as a modern three-year-old, and its brain was as small as the smallest australopithecine brain known. There were other primitive traits as well, including the broad pelvis and the long neck of the femur. In other respects, however, the specimen looked familiar. Its small teeth and narrow nose, the overall shape of the braincase and the thickness of the cranial bones all evoked *Homo*.

Brown spent the next three months analyzing the enigmatic skeleton, catalogued as LB1 and affectionately nicknamed the Hobbit by some of the team members, after the tiny beings in J.R.R. Tolkien's *The Lord of the Rings* books. The decision about how to classify it did not come easily. Impressed with the characteristics LB1 shared with early hominids such

PORTIA SLOAN



DWARFS AND GIANTS tend to evolve on islands, with animals larger than rabbits shrinking and animals smaller than rabbits growing. The shifts appear to be adaptive responses to the limited food supplies available in such environments. *Stegodon,* an extinct proboscidean, colonized Flores several times, dwindling from elephant to water buffalo proportions. Some rats, in contrast, became rabbit-sized over time. *H. floresiensis* appears to have followed the island rule as well. It is thought to be a dwarfed descendant of *H. erectus,* which itself was nearly the size of a modern human.



SHARED FEATURES between LB1 and members of our own genus led to the classification of the Flores hominid as *Homo,* despite its tiny brain size. Noting that the specimen most closely resembles *H. erectus,* the researchers posit that it is a new species, *H. floresiensis,* that dwarfed from a *H. erectus* ancestor. *H. floresiensis* differs from *H. sapiens* in having, among other characteristics, no chin, a relatively projecting face, a prominent brow and a low braincase.

as the australopithecines, he initially proposed that it represented a new genus of human. On further consideration, however, the similarities to *Homo* proved more persuasive. Based on the 18,000-year age of LB1, one might have reasonably expected the bones to belong to *H. sapiens,* albeit a very petite representative. But when Brown and his colleagues considered the morphological characteristics of small-bodied modern humans—including normal ones, such as pygmies, and abnormal ones, such as pituitary dwarfs—LB1 did not seem to fit any of those descriptions. Pygmies have small bodies and large brains—the result of delayed growth during puberty, when the brain has already attained its full size. And individuals with genetic disorders that produce short stature and small brains have a range of distinctive features not seen in LB1 and rarely reach adulthood, Brown says. Conversely, he notes, the Flores skeleton exhibits archaic traits that have never been documented for abnormal small-bodied *H. sapiens*.

What LB1 looks like most, the researchers concluded, is a miniature *H. erectus*. Describing the find in the journal *Nature,* they assigned LB1 as well as the isolated tooth and an arm bone from older deposits to a new species of human, *Homo floresiensis*. They further argued that it was a descendant of *H. erectus* that had become marooned on Flores and evolved in isolation into a dwarf species, much as the elephantlike *Stegodon* did.

Biologists have long recognized that mammals larger than rabbits tend to shrink on small islands, presumably as an adaptive response to the limited food supply. They have little to lose by doing so, because these environments harbor few predators. On Flores, the only sizable predators were the Komodo dragon and another, even larger monitor lizard. Animals smaller than rabbits, on the other hand, tend to attain brobdingnagian proportions—perhaps because bigger bodies are more energetically efficient than small ones. Liang Bua has yielded evidence of that as well, in the form of a rat as robust as a rabbit.

But attributing a hominid's bantam size to the so-called island rule was a first. Received paleoanthropological wisdom holds that culture has buffered us humans from many of the selective pressures that mold other creatures—we cope with cold, for example, by building fires and making clothes, rather than evolving a proper pelage. The discovery of a dwarf hominid species indicates that, under the right conditions, humans can in fact respond in the same, predictable way that other large mammals do when the going gets tough. Hints that *Homo* could deal with resource fluxes in this manner came earlier in 2004 from the discovery of a relatively petite *H. erectus* skull from Olorgesailie in Kenya, remarks Richard Potts of the Smithsonian Institution, whose team recovered the bones. "Getting small is one of the things *H. erectus* had in its biological tool kit," he says, and the Flores hominid seems to be an extreme instance of that.

CHRISTIAN SIDOR *New York College of Osteopathic Medicine* (*H. sapiens*); PETER BROWN *University of New England, Armidale* AND TIMEFORKIDS/KRT (*H. floresiensis*); DAVID BRILL (*H. erectus*)

Curiouser and Curiouser

H. FLORESIENSIS's teeny brain was perplexing. What the hominid reportedly managed to accomplish with such a modest organ was nothing less than astonishing. Big brains are a hallmark of human evolution. In the space of six million to seven million years, our ancestors more than tripled their cranial capacity, from some 360 cubic centimeters in *Sahelanthropus,* the earliest putative hominid, to a whopping 1,350 cubic centimeters on average in modern folks. Archaeological evidence indicates that behavioral complexity increased correspondingly. Experts were thus fairly certain that large brains are a prerequisite for advanced cultural practices. Yet whereas the pea-brained australopithecines left behind only crude stone tools at best (and most seem not to have done any stone working at all), the comparably gray-matter-impoverished *H. floresiensis* is said to have manufactured implements that exhibit a level of sophistication elsewhere associated exclusively with *H. sapiens*.

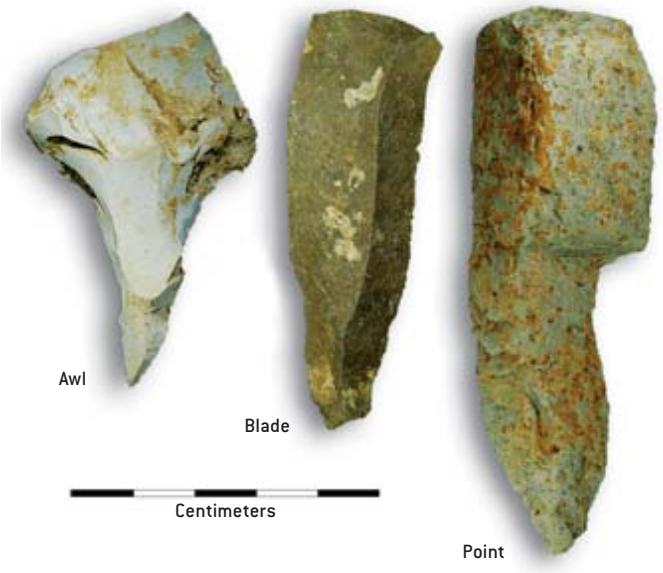
The bulk of the artifacts from Liang Bua are simple flake tools struck from volcanic rock and chert, no more advanced than the implements made by late australopithecines and early *Homo*. But mixed in among the pygmy *Stegodon* remains excavators found a fancier set of tools, one that included finely worked points, large blades, awls and small blades that may have been hafted for use as spears. To the team, this association suggests that *H. floresiensis* regularly hunted *Stegodon*. Many of the *Stegodon* bones are those of young individuals that one *H. floresiensis* might have been able to bring down alone. But some belonged to adults that weighed up to half a ton, the hunting and transport of which must have been a coordinated group activity—one that probably required language, surmises team member Richard G. ("Bert") Roberts of the University of Wollongong in Australia.

The discovery of charred animal remains in the cave suggests that cooking, too, was part of the cultural repertoire of *H. floresiensis*. That a hominid as cerebrally limited as this one might have had control of fire gives pause. Humans are not thought to have tamed flame until relatively late in our collective cognitive development: the earliest unequivocal evidence of fire use comes from 200,000-year-old hearths in Europe that were the handiwork of the large-brained Neandertals.

If the *H. floresiensis* discoverers are correct in their interpretation, theirs is one of the most important paleoanthropological finds in decades. Not only does it mean that another species of human coexisted with our ancestors just yesterday in geological terms, and that our genus is far more variable than expected, it raises all sorts of questions about brain size and intelligence. Perhaps it should come as no surprise, then, that controversy has accompanied their claims.

Classification Clash

IT DID NOT TAKE LONG for alternative theories to surface. In a letter that ran in the October 31 edition of Australia's *Sunday Mail,* just three days after the publication of the *Nature* issue containing the initial reports, paleoanthropologist Maciej Henneberg of the University of Adelaide countered that



ADVANCED IMPLEMENTS appear to have been the handiwork of *H. floresiensis.* Earlier hominids with brains similar in size to that of *H. floresiensis* made only simple flake tools at most. But in the same stratigraphic levels as the hominid remains at Liang Bua, researchers found a suite of sophisticated artifacts—including awls, blades and points—exhibiting a level of complexity previously thought to be the sole purview of *H. sapiens.*

a pathological condition known as microcephaly (from the Greek for "small brain") could explain LB1's unusual features. Individuals afflicted with the most severe congenital form of microcephaly, primordial microcephalic dwarfism, die in childhood. But those with milder forms, though mentally retarded, can survive into adulthood. Statistically comparing the head and face dimensions of LB1 with those of a 4,000-year-old skull from Crete that is known to have belonged to a microcephalic, Henneberg found no significant differences between the two. Furthermore, he argued, the isolated forearm bone found deeper in the deposit corresponds to a height of 151 to 162 centimeters—the stature of many modern women and some men, not that of a dwarf—suggesting that larger-bodied people, too, lived at Liang Bua. In Henneberg's view, these findings indicate that LB1 is more likely a microcephalic *H. sapiens* than a new branch of *Homo*.

Susan C. Antón of New York University disagrees with that assessment. "The facial morphology is completely different in microcephalic [modern] humans," and their body size is normal, not small, she says. Antón questions whether LB1 warrants a new species, however. "There's little in the shape that differentiates it from *Homo erectus*," she notes. One can argue that it's a new species, Antón allows, but the difference in shape between LB1 and *Homo erectus* is less striking than that between a Great Dane and a Chihuahua. The possibility exists that the LB1 specimen is a *H. erectus* individual with a pathological growth condition stemming

COURTESY OF MARK MOORE

from microcephaly or nutritional deprivation, she observes.

But some specialists say the Flores hominid's anatomy exhibits a more primitive pattern. According to Colin P. Groves of the Australian National University and David W. Cameron of the University of Sydney, the small brain, the long neck of the femur and other characteristics suggest an ancestor along the lines of *Homo habilis,* the earliest member of our genus, rather than the more advanced *H. erectus.* Milford H. Wolpoff of the University of Michigan at Ann Arbor wonders whether the Flores find might even represent an offshoot of *Australopithecus.* If LB1 is a descendant of *H. sapiens* or *H. erectus,* it is hard to imagine how natural selection left her with a brain that's even smaller than expected for her height, Wolpoff says. Granted, if she descended from *Australopithecus,* which had massive jaws and teeth, one has to account for her relatively delicate jaws and dainty dentition. That, however, is a lesser evolutionary conundrum than the one posed by her tiny brain, he asserts. After all, a shift in diet could explain the reduced chewing apparatus, but why would selection downsize intelligence?

Finding an australopithecine that lived outside of Africa—not to mention all the way over in Southeast Asia—18,000 years ago would be a first. Members of this group were thought to have died out in Africa one and a half million years ago, never having left their mother continent. Perhaps, researchers reasoned, hominids needed long, striding limbs, large brains and better technology before they could venture out into the rest of the Old World. But the recent discovery of 1.8 million-year-old *Homo* fossils at a site called Dmanisi in the Republic of Georgia refuted that explanation—the Georgian hominids were primitive and small and utilized tools like those australopithecines had made a million years before. Taking that into consideration, there is no a priori reason why australopithecines (or habilines, for that matter) could not have colonized other continents.

Troubling Tools

YET IF *AUSTRALOPITHECUS* made it out of Africa and survived on Flores until quite recently, that would raise the question of why no other remains supporting that scenario have turned up in the region. According to Wolpoff, they may have: a handful of poorly studied Indonesian fossils discovered in the 1940s have been variously classified as *Australopithecus, Meganthropus* and, most recently, *H. erectus.* In light of the Flores find, he says, those remains deserve reexamination.

Many experts not involved in the discovery back Brown and Morwood's taxonomic decision, however. "Most of the differences [between the Flores hominid and known members of *Homo*], including apparent similarities to australopithecines, are almost certainly related to very small body mass," declares David R. Begun of the University of Toronto. That is, as the Flores people dwarfed from *H. erectus,* some of their anatomy simply converged on that of the likewise little australopithecines. Because LB1 shares some key derived features with *H. erectus* and some with other members of *Homo,* "the most straightforward option is to call it a new species of *Homo,*" he remarks. "It's a fair and reasonable interpretation," *H. erectus* expert G. Philip Rightmire of Binghamton University agrees. "That was quite a little experiment in Indonesia."

Even more controversial than the position of the half-pint human on the family tree is the notion that it made those advanced-looking tools. Stanford University paleoanthropologist Richard Klein notes that the artifacts found near LB1

Home of the Hobbit

Scholars were stunned a decade ago to learn that *H. erectus* might have survived on the island of Java in Indonesia until 25,000 years ago, well after the arrival of *H. sapiens* in the region and even after the disappearance of Europe's Neandertals. The recent revelation that a third hominid, dubbed *H. floresiensis,* lived in the area until just 13,000 years ago has proved even more provocative.

Archaeologists recovered the remains from a large limestone cave known as Liang Bua located in western Flores. No one knows exactly how humans first reached the island—they may have made the requisite sea crossings by boat, or they may have drifted over on natural rafts quite by accident.

Geographically, Javan *H. erectus* is a good candidate for the ancestor of *H. floresiensis.* But resemblances to specimens from Africa and the Republic of Georgia raise the question of whether *H. floresiensis* stemmed from a different hominid migration into Southeast Asia from the one that gave rise to Javan *H. erectus.* Future excavations on Flores and other Indonesian islands (*detail*) may cast light on these mysteries.

HANDOUT/REUTERS/CORBIS (*cave*); LAURIE GRACE AND EDWARD BELL (*maps*)

appear to include few, if any, of the sophisticated types found elsewhere in the cave. This brings up the possibility that the modern-looking tools were produced by modern humans, who could have occupied the cave at a different time. Further excavations are necessary to determine the stratigraphic relation between the implements and the hominid remains, Klein opines. Such efforts may turn up modern humans like us. The question then, he says, will be whether there were two species at the site or whether modern humans alone occupied Liang Bua—in which case LB1 was simply a modern who experienced a growth anomaly.

Stratigraphic concerns aside, the tools are too advanced and too large to make manufacture by a primitive, diminutive hominid likely, Groves contends. Although the Liang Bua implements allegedly date back as far as 94,000 years ago, which the team argues makes them too early to be the handiwork of

H. sapiens, Groves points out that 67,000-year-old tools have turned up in Liujiang, China, and older indications of a modern human presence in the Far East might yet emerge. "*H. sapiens*, once it was out of Africa, didn't take long to spread into eastern Asia," he comments.

"At the moment there isn't enough evidence" to establish that *H. floresiensis* created the advanced tools, concurs Bernard Wood of George Washington University. But as a thought experiment, he says, "let's pretend that they did." In that case, "I don't have a clue about brain size and ability," he confesses. If a hominid with no more gray matter than a chimp has can create a material culture like this one, Wood contemplates, "why did it take people such a bloody long time to make tools" in the first place?

"If *Homo floresiensis* was capable of producing sophisticated tools, we have to say that brain size doesn't add up to much," Rightmire concludes. Of course, humans today exhibit considerable variation in gray matter volume, and great thinkers exist at both ends of the spectrum. French writer Jacques Anatole François Thibault (also known as Anatole France), who won the 1921 Nobel Prize for Literature, had a cranial capacity of only about 1,000 cubic centimeters; England's General Oliver Cromwell had more than twice that. "What that means is that once you get the brain to a certain size, size no longer matters, it's the organization of the brain," Potts states. At some point, he adds, "the internal wiring of the brain may allow competence even if the brain seems small."

LB1's brain is long gone, so how it was wired will remain a mystery. Clues to its organization may reside on the interior of the braincase, however. Paleontologists can sometimes obtain latex molds of the insides of fossil skulls and then create plaster endocasts that reveal the morphology of the organ. Because LB1's bones are too fragile to withstand standard casting procedures, Brown is working on creating a virtual endocast based on CT scans of the skull that he can then use to generate a physical endocast via stereolithography, a rapid-prototyping technology.

"If it's a little miniature version of an adult human brain, I'll be really blown away," says paleoneurologist Dean Falk of the University of Florida. Then again, she muses, what happens if the convolutions look chimplike? Specialists have long wondered whether bigger brains fold differently simply because they are bigger or whether the reorganization reflects selection for increased cognition. "This specimen could conceivably answer that," Falk observes.

Return to the Lost World

SINCE SUBMITTING their technical papers to *Nature*, the Liang Bua excavators have reportedly recovered the remains of another five or so individuals, all of which fit the *H. floresiensis* profile. None are nearly so complete as LB1, whose long arms turned up during the most recent field season. But they did unearth a second lower jaw that they say is identical in size and shape to LB1's. Such duplicate bones will be critical to their case that they have a population of these tiny humans (as opposed to a bunch of scattered bones from one person). That should in turn dispel concerns that LB1 was a diseased individual.

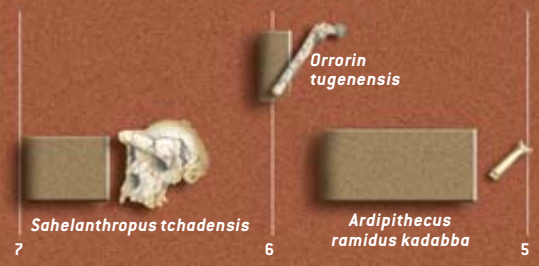
Additional evidence may come from DNA: hair samples possibly from *H. floresiensis* are undergoing analysis at the University of Oxford, and the hominid teeth and bones may contain viable DNA as well. "Tropical environments are not the best for long-term preservation of DNA, so we're not holding our breath," Roberts remarks, "but there's certainly no harm in looking."

The future of the bones (and any DNA they contain) is uncertain, however. In late November, Teuku Jacob of the Gadjah Mada University in Yogyakarta, Java, who was not involved in the discovery or the analyses, had the delicate specimens transported from their repository at the Indonesian Center for Archaeology to his own laboratory with Soejono's assistance. Jacob, the dean of Indonesian paleoanthropology, thinks LB1 was a microcephalic and allegedly ordered the transfer of it and the new, as yet undescribed finds for examination and safekeeping, despite strong objections from other staff members at the center. At the time this article was going to press, the team was waiting for Jacob to make good on his promise to return the remains to Jakarta by January 1 of this year, but his reputation for restricting scientific access to fossils has prompted pundits to predict that the bones will never be studied again.

Efforts to piece together the *H. floresiensis* puzzle will proceed, however. For his part, Brown is eager to find the tiny hominid's large-bodied forebears. The possibilities are three-

The Times of Their Lives

Adding a twig to the family tree of humans, Peter Brown of the University of New England in Armidale, Australia, and his colleagues diagnosed the hominid remains from Flores as a new species of Homo, *H. floresiensis*. This brings the number of hominid forms alive at the time of early *H. sapiens* to four if Neandertals are considered a species separate from our own, as shown here. Brown believes that *H. floresiensis* descended from *H. erectus* (*inset*). Others hypothesize that it is an aberrant *H. sapiens* or *H. erectus* or an offshoot of the earlier and more primitive habilines or australopithecines.



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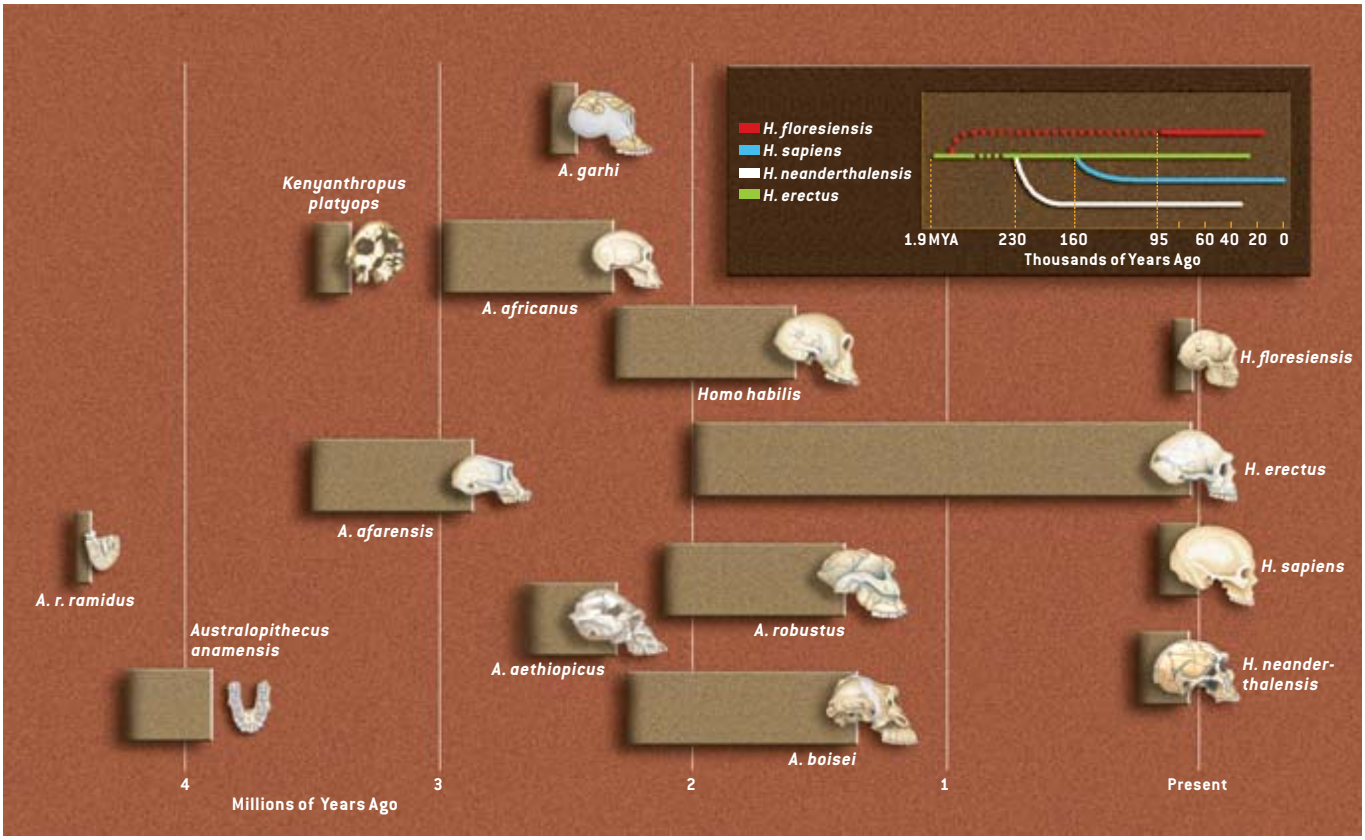

fold, he notes. Either the ancestor dwarfed on Flores (and was possibly the maker of the 840,000-year-old Soa Basin tools), or it dwindled on another island and later reached Flores, or the ancestor was small before it even arrived in Southeast Asia. In fact, in many ways, LB1 more closely resembles African *H. erectus* and the Georgian hominids than the geographically closer Javan *H. erectus,* he observes. But whether these similarities indicate that *H. floresiensis* arose from an earlier *H. erectus* foray into Southeast Asia than the one that produced Javan *H. erectus* or are merely coincidental results of the dwarfing process remains to be determined. Future excavations may connect the dots. The team plans to continue digging on Flores and Java and will next year begin work on other Indonesian islands, including Sulawesi to the north.

The hominid bones from Liang Bua now span the period from 95,000 to 13,000 years ago, suggesting to the team that the little Floresians perished along with the pygmy *Stegodon* because of a massive volcanic eruption in the area around 12,000 years ago, although they may have survived later farther east. If *H. erectus* persisted on nearby Java until 25,000 years ago, as some evidence suggests, and *H. sapiens* had arrived in the region by 40,000 years ago, three human species lived cheek by jowl in Southeast Asia for at least 15,000 years. And the discoverers of *H. floresiensis* predict that more will be found. The islands of Lombok and Sumbawa would have been natural stepping-stones for hominids traveling from Java or mainland Asia to Flores. Those that put down roots on these islands may well have set off on their own evolutionary trajectories.

Perhaps, it has been proposed, some of these offshoots of the *Homo* lineage survived until historic times. Maybe they still live in remote pockets of Southeast Asia's dense rain forests, awaiting (or avoiding) discovery. On Flores, oral histories hold that the *ebu gogo* was still in existence when Dutch colonists settled there in the 19th century. And Malay folklore describes another small, humanlike being known as the *orang pendek* that supposedly dwells on Sumatra to this day.

"Every country seems to have myths about these things," Brown reflects. "We've excavated a lot of sites around the world, and we've never found them. But then [in September 2003] we found LB1." Scientists may never know whether tales of the *ebu gogo* and *orang pendek* do in fact recount actual sightings of other hominid species, but the newfound possibility will no doubt spur efforts to find such creatures for generations to come. SA

Kate Wong is editorial director of ScientificAmerican.com

MORE TO EXPLORE

Archaeology and Age of a New Hominin from Flores in Eastern Indonesia. M. J. Morwood et al. in *Nature,* Vol. 431, pages 1087–1091; October 28, 2004.

A New Small-Bodied Hominin from the Late Pleistocene of Flores, Indonesia. P. Brown et al. in *Nature,* Vol. 431, pages 1055–1061; October 28, 2004.

A Q&A with Peter Brown is at **www.sciam.com/ontheweb**