Do Ape-Size Legs Mean Ape-Like Gait?

One calculation shows 3-million-year-old Lucy to have ape-size legs; ape-size they might be, but this carries no significance, indicates another

"The question is," asks Milford Wolpoff of the University of Michigan, "does Lucy have short legs relative to her arms, or are her arms long in relation to her legs?" Lucy, of course, is the 3-million-year-old partial skeleton of a human ancestor discovered almost a decade ago in Ethiopia. The fact that the remains included leg and arm bones offered the potentially rewarding possibility of deriving relative limb length comparisons with those of modern humans, a paleontological bonus that is only now being fully explored. "Bill [Jungers] has turned the focus on Lucy's short legs," says Wolpoff. "That is a terrific idea, but I think he's wrong in the way he's done it."

Comparing limb lengths one with another in a fossil skeleton like Lucy and assessing them in relation to similar measures in modern humans and apes is useful only if it reveals something about function, about how the animal moved around. Jungers, for instance, has recently concluded that "the relatively short hindlimb of Lucy implies substantial kinematic differences in bipedal gait from the modern condition." In other words, although members of *Australopithecus afarensis*, the species to which Lucy belonged, walked upright on two legs, the process was less efficient energetically than in *Homo sapiens*, according to Jungers.

The inference from the ape-like proportions of Lucy's hindlimb is that her species had not yet reached "a fully modern adaptation to bipedalism," says Jungers. And he suggests that "Dramatic hindlimb elongation (absolutely and relatively) emerges as one of the major evolutionary changes from *A. afarensis* to modern humans."

Wolpoff agrees that dramatic leg elongation has occurred between *A. afarensis* and *Homo sapiens* but argues that this is simply a corollary of body size increase. "[Lucy's] legs are shown to be about the length one would expect in a modern human of her diminutive weight," he says. "That they also happen to be the length of a chimpanzee's with similar body weight is irrelevant with regard to Lucy's locomotion."

These differences of opinion, which extend the arguments debated at the Institute of Human Origins' symposium on hominid locomotion held earlier this year in Berkeley (*Science*, 13 May, p. 700), have arisen through differences in interpretation of material with which Lucy's limbs were compared.

In his calculations, which were recently reported in *Nature*, Jungers compared the length of Lucy's femur with an African ape standard (a chimpanzee for example) computed to the same body size. There was virtually no difference between the two, just as there was in the comparison of the figures from a pygmy chimpanzee and its larger relative. By contrast, a single example of a Mbuti Pygmy female (as an example of *Homo sapiens* of about the same body weight as Lucy, that is 27.3 to 30.9 kg as against 25.0 to 30.0 kg), had a femur 21.1 to 23.3 percent longer than the ape standard. Lucy's legs were clearly diminutive and more like those of an ape than a human, concluded Jungers.

Wolpoff's response, which will be published in the *Journal of Human Evolution*, is that a more extensive comparison of Lucy's measurements with Pygmy data show the primitive hominid to have walked on legs of surprisingly modern proportions. Jungers' estimate for the weight of his single Pygmy female comparison was too low by at least 30 percent, contends Wolpoff. Taking this into account the Pygmy's femur then comes out to be only 14 percent longer than an ape of the same body size.

Wolpoff develops this line of argument further and notes that the 14 percent deviation from the ape standard for the pygmy is only one-third the deviation seen in European females. "This raises the possibility that the deviation decreases with decrease in body size." In other words, the smaller you are the smaller yet are your legs. "The question is, how short would a human femur be in individuals as small as Lucy?"

To answer this question Wolpoff took data from 15 Pygmy skeletons and, through a somewhat convoluted set of statistical manipulations, estimated their body weights and derived the deviations from the African ape standard. Using the regression developed by plotting deviation as a function of weight, Wolpoff obtained a femur length 4.9 percent longer than the ape standard for a human with a body the size of Lucy's. When data from male and female Europeans were included, a 6.5 percent deviation emerged. "Thus, in terms of deviation from the expectations based on African ape allometry, Lucy's femur is within about 5 percent the value one would expect in a human of the same size."

The real issue in all this is, how did Lucy walk? What kind of biped was she, for no one denies she walked upright.

If, as Jungers says, Lucy's hindlimb proportions are ape-like, then perhaps her bipedal gait had simian nuances. Randall Susman and Jack Stern, colleagues of Jungers at the State University of New York at Stony Brook, argued at the Berkeley conference that there is a diversity of evidence suggesting a partial bent-hip/bent-knee gait in *A. afarensis*. Owen Lovejoy, of Kent State University, counter-argued for a more or less fully modern bipedalism, drawing on knee, hip, and pelvis structure. Wolpoff's conclusion from limb proportions aligns itself with Lovejoy's view.

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If Lovejoy and Wolpoff are correct, what can be said about the energetics of a striding gait in the diminutive bodies of *A. afarensis*? Unlike the leg-swing in quadrapedal animals, which is powered by muscle contraction, in humans walking with a striding gait the swing is free like a pendulum after an initial muscular propulsion. The momentum of the swing will depend on the length of the leg and its weight. And the greater the momentum the greater the energetic efficiency. No one denies that Lucy's legs were small, but what of their weight?

Wolpoff presents data that, he says, show Lucy to have been of a much more robust build than any modern human. For instance, the midshaft circumference of a Pygmy's femur is, on average, 18.4 percent of its length; this compares with 25.3 percent for Lucy. The same figures for the humerus are 17.4 percent in Pygmies and 23.0 percent in Lucy. Cortical bone is thicker in *A. afarensis* than in modern humans too, says Wolpoff. He concludes from all this that Lucy and her fellows, like all hominid species until the advent of *Homo sapiens*, was heavily muscled. And this heavy musculature would form substantial bulk in the lower limb that would enhance momentum in its forward swing. Wolpoff says, however, that without more information on the distribution of weight in the lower limb it is not feasible to do any detailed energetic comparisons with modern human forms. "All you can say at the moment is that there is nothing to show that she was different."

Although Lucy's arms are within the human range (measured by comparing the humerus length with that of a range of Pygmies), they are relatively long for the rest of her body. This, combined with the robusticity of the arm bones and certain anatomical features of the forelimb, leads Wolpoff to suggest that these early hominids were adept and frequent tree-climbers, a conclusion that Stern and Susman have reached and was debated vigorously at the Berkeley meeting. On that occasion, however, the focus of the discussions was the curved feet and hand bones, which Wolpoff does not address.

Russell Tuttle, of the University of Chicago, has been promoting for some time the notion of a small, tree-climbing ancestor to hominids (ape-like but definitely not an ape). "I like this idea," says Wolpoff, "and it is interesting to consider Lucy as something close to the common ancestor of the hominids and African apes." If, as Wolpoff argues, Lucy's diminutive, small-legged frame is transformed into the long-legged strider of modern humans by simple allometric increase of body size, then one can view the legs of a Lucy-size, ape-like hominid ancestor as being "preadapted" to bipedal striding.

Wolpoff also sees many of the major divergent features of anatomy that separate humans and modern African apes as the result of body size increase in the two lineages, each of which is adapted to a particular form of locomotion: hominids being bipedal, and apes being quadrapedal tree-climbers. Specifically, the long arms, long fingers and short thumbs, and reduced lower back in apes contrast with humans and appear to be mechanical adaptations to the demands of arboreality.

The Asian great ape, the orangutan, shares many anatomical features with its African cousins that are not present in their ancestors, specifically these last mentioned. Which might be considered a problem. If, as now seems certain, the African apes and hominids are more closely related to each other than any is to the orangutan, how is one to explain the occurrence of this group of features throughout all the great apes and its absence in Lucy and her descendants?

Wolpoff argues that they are parallel adaptations in separate lineages. "The parallelisms can . . . be explained as similar responses to similar locomotor adaptations necessitated by the biomechanical requirements of increasing size." The modern great apes do not make good comparisons either anatomically or behaviorally for the common ancestor as their body-size increase since diverging from the ancestral line has wrought many specializations that simply were not present earlier, says Wolpoff.—ROGER LEWIN

Cell Surgery to Reconnect Nerves

A new method of reconnecting peripheral nerves virtually ensures that they will grow back correctly

Luis de Medinaceli, William J. Freed, and Richard Jed Wyatt of the National Institute of Mental Health (NIMH) at Saint Elizabeths Hospital have developed a system that virtually guarantees that severed peripheral nerves will reconnect so as to allow them to function. In contrast, the surgical methods now used to reconnect such nerves are successful only 15 percent of the time. The NIMH researchers have discussed their work with Anthony Seaber of Duke University, who has now replicated their results. "It looks totally practical. It's very good," Seaber remarks.

De Medinaceli joined the NIMH in 1979 after spending 15 years as a surgeon in Europe. For 15 years he had tried, with little success, to develop an effective way to get peripheral nerves to connect. Now that he has succeeded he points out that almost nothing in his method is really new. "Everything has been described by someone else. What is new is putting all of it together," he says. He credits, in particular, the work of William Schlaepper of the University of Pennsylvania, who showed the damaging effects of chemical and ionic changes on nerve fibers as well as older work by L. Van den Berg of the National Research Council of Ottawa and A. Leaf of Oxford University. He also credits Carmine Clemente of the University of California at Los Angeles, Richard Bunge of Washington University, and Albert J. Aguys of McGill University.

Physiologists divide the nervous system into two parts: the central nervous system and the peripheral nerves. The central nervous system consists of the brain and spinal cord. The peripheral nerves come out of the spinal cord, allowing muscles to move on command and carrying the sensations of touch and pain. Injuries to peripheral nerves are fairly common—the nerves are often cut in car accidents or industrial accidents, for example—and once severed they usually do not function again.

But peripheral nerves, unlike spinal cord nerves, do grow after an injury and they grow well. The problem, says de Medinaceli, is that "the fibers have no way to know where to go when they grow back. You can imagine a peripheral nerve as a big telephone cable, with a sheath around it and with individual wires inside, each with its own wrapping." Typically each peripheral nerve contains tens of thousands of individual nerve fibers. The sciatic nerve in the leg, which is the largest peripheral nerve, may contain up to 175,000 fibers. When the nerve is severed, the cut is ragged. For function to be restored, the fibers must make proper connections across a large gap that usually contains blood and scar tissue.

In his attempts to get peripheral nerves to reconnect properly, de Medinaceli decided to follow a single guiding