ence 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.

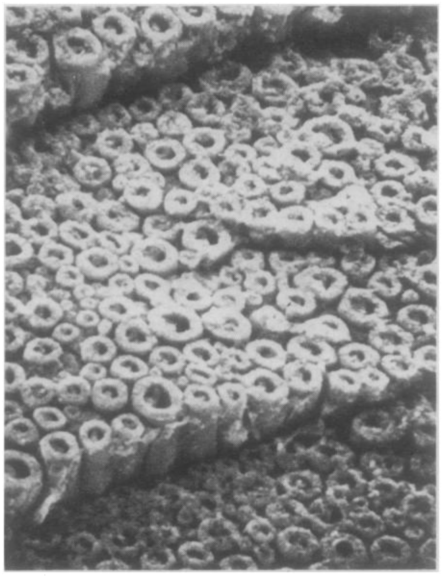
In his attempts to get peripheral nerves to reconnect properly, de Medinaceli decided to follow a single guiding principle. "When you see a severed blood vessel, a cut nerve, or a fractured bone, the general mental image is of similarity—the structure is severed and it must be repaired. But there is a fundamental difference. When an artery or a bone is cut, what is cut are tissues. When a nerve fiber is cut, what is cut is one cell. To repair an artery or bone, you use tissue surgery. But wouldn't it be necessary to apply cellular surgery to a nerve?"

De Medinaceli decided first of all not to try to suture the nerve stumps together. Surgeons have tried that, even going so far as to individually suture the nerve bundles together. But, of course, they could never suture the tiny and numerous nerve fibers. As a result, the nerve fibers have to grow across a large gap and the sutures always place stress at the area of the cut. Another method he avoided was using some sort of glue, such as blood or the blood protein fibrin. With glue, as with sutures, "what we get is always a space—the fibers have to jump it."

De Medinaceli decided to hold the cut nerves together by using a rubber support attached at some distance on either side of the injury. He modified his device until it pushed the nerves together with just enough pressure to hold them in place but with not enough pressure to distort them. The nerves looked good. There was no space between them. But they still did not reconnect properly. (To emphasize his point that he relied heavily on reports in the literature, de Medinaceli notes that the idea of holding rather than sewing severed nerves together was first proposed in 1864 but was rejected as ineffective.)

Then de Medinaceli decided to refine the method of cutting. No matter how carefully he cut the peripheral nerves with a scalpel, the cut is not regular. "Imagine each nerve fiber as a strand of cooked spaghetti," he says, "Then imagine cutting a bundle of spaghetti with shears. At best you get a jagged edge but you also crush the nerves. Every time you try to shave off the nerve edges, you crush the nerve again." Freed elaborates, "Before you cut the fibers, the pressure of the blade squeezes and just smashes the nerves. Surgeons who sew these nerves together are suturing cadavers. The tissue they have trimmed very carefully is dead. And every attempt to trim the stumps further extends the damage. When the nerves try to reconnect, they have to jump across dead tissue."

So the next attempt of the NIMH group was to freeze the cut nerves and


Plastic and Reconstructive Surgery

A severed nerve

This photomicrograph shows the multiplicity and diversity of individual nerve axons that must be reconnected if function is to be restored to a severed nerve bundle.

then to trim them with a vibrating blade like an electric carving knife. It looked as if it would work quite well. The frozen nerves were stiff so they did not twist and the rotating blade produced a clean cut. Then the researchers held the two pieces of cut nerves together with their rubber device. But the results were no better—the nerves failed to regain their function and there was a large gap of dead tissue at the point where the nerves were joined. "The kind of repair I was so proud of was dead after 10 hours. We had avoided the irregularities of the cut and crush damage from cutting but the results were just as bad as ever."

Finally, de Medinaceli hit upon a new tack. "Until now we have used rules of tissue surgery and that is not right. We had to define and then apply rules of cellular surgery. The concentrations of ions are *very* different inside and outside of cells. If you cut a nerve fiber, the ions that are inside go out and those outside come in. If you do that to an amoeba—prick a hole in it—it will die. If you do it to a nerve fiber, it manages to survive but you get a chemical burn at the tip and the tip dies."

He decided that what he had to do is to keep the interior of the nerve fiber from losing its chemical and ionic balance. It is like opening a wine bottle in a swimming pool, he says. If you do that, the wine goes out and water comes in. The only way to be sure that the bottle remains filled with wine is to open it in a pool of wine. So he and his colleagues decided to bathe the nerve fibers in solutions that mimic the inside of a nerve cell. They learned that unless the nerve is cooled, this solution could kill it but, fortunately, they had already developed the method of freezing nerves in order to trim them.

The NIMH scientists put it all together. They froze the nerves, soaked them in a solution that resembles the inside of a cell, cut the nerves with a vibrating blade, and held the cut edges together with a rubber device. The results were spectacular. They tried the method on 13 rats by cutting their sciatic nerves, which goes through the hind limb and is necessary for walking. All 13 regained their ability to walk without a limp within 1 month, although the NIMH researchers could show that the animals still had slight deficits. In comparisons, only three out of ten rats whose nerves had been cut in a conventional way by an accomplished neurosurgeon in Seaber's group at Duke and then had been sewn together by this surgeon could not move their legs at all after 2½ months.

"I have done this experiment over and over again to convince myself and it always works," de Medinaceli says. He has even showed that it works in situations resembling real injuries in which he cuts the nerves and then waits more than 2 hours before repairing them. Seaber also gets good results with the new method. "I personally have duplicated his results. We get total movement back in 18 to 25 days whereas none of our controls regain movement. The histology also looks very very good. The alignment of the axons is incredibly straight and there is hardly any scar tissue. It's stunning." When Seaber asked five surgeons to look at the repaired sciatic nerves, several could not even see where the nerves were cut. Conventional methods of suturing these nerves leave extensive scar tissue.

The next step is to try the new method with nonhuman primates and then to use it with human patients. It also is possible that this idea of using cellular surgery might be applicable to spinal cord neurons. "The physiology, the anatomy, the whole world of spinal cord neurons is obviously different," Seaber says. "In order of magnitude we're talking of orbiting the earth with a satellite as compared to standing on the moon and collecting moon rocks. There is a difference. But it's all in orbiting the earth first."—**Gina Kolata**

Additional Reading

1. L. de Medinaceli and W. J. Freed, "Peripheral nerve reconnection (I)," *Exp. Neurol.* **81**, 459–468 (1983).
2. L. de Medinaceli, W. J. Freed, R. J. Wyatt, "Peripheral nerve reconnection (II)," *ibid.*, pp. 469–487.
3. ______, "Peripheral nerve reconnection (III)," *ibid.*, pp. 488–496.