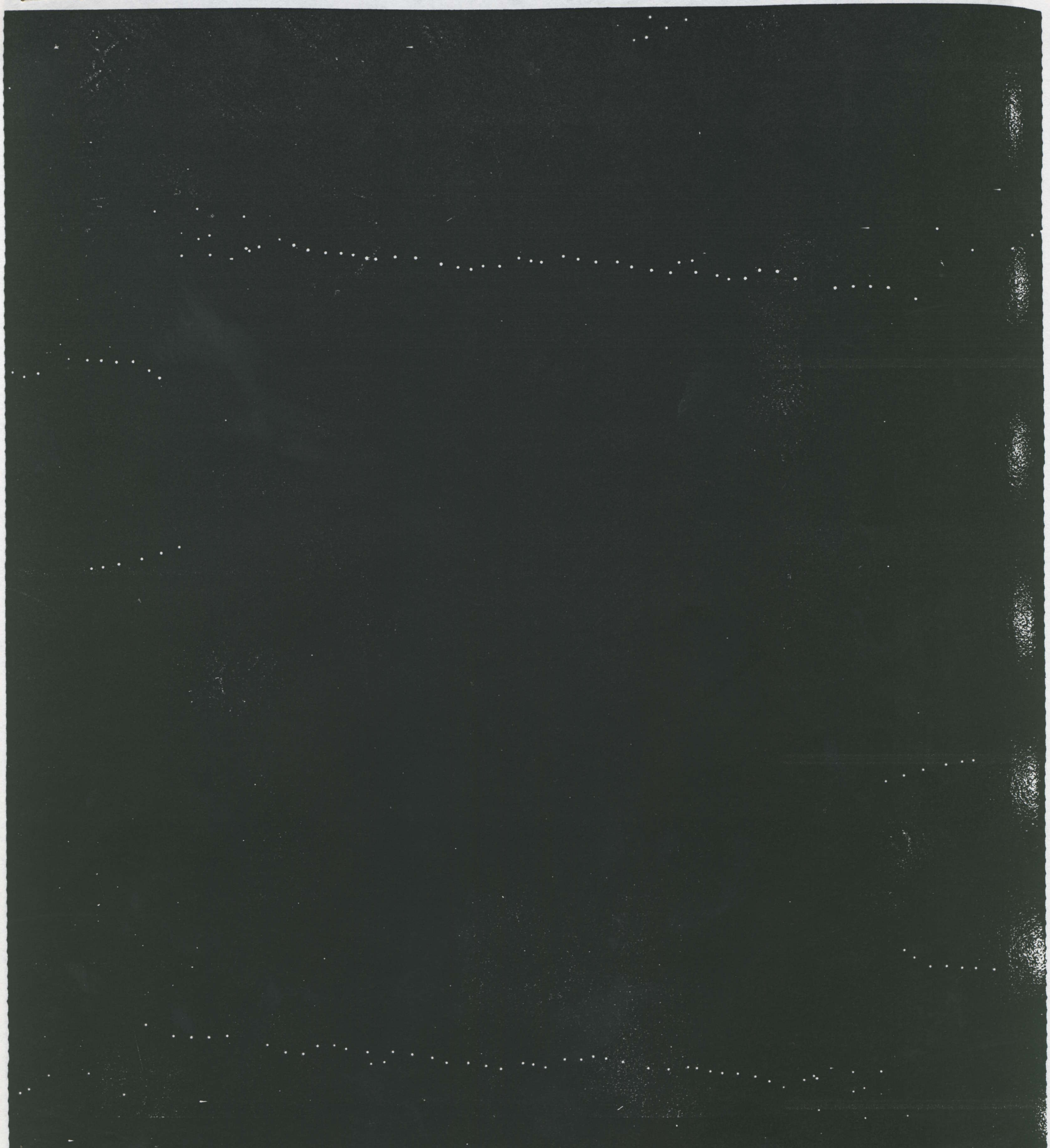
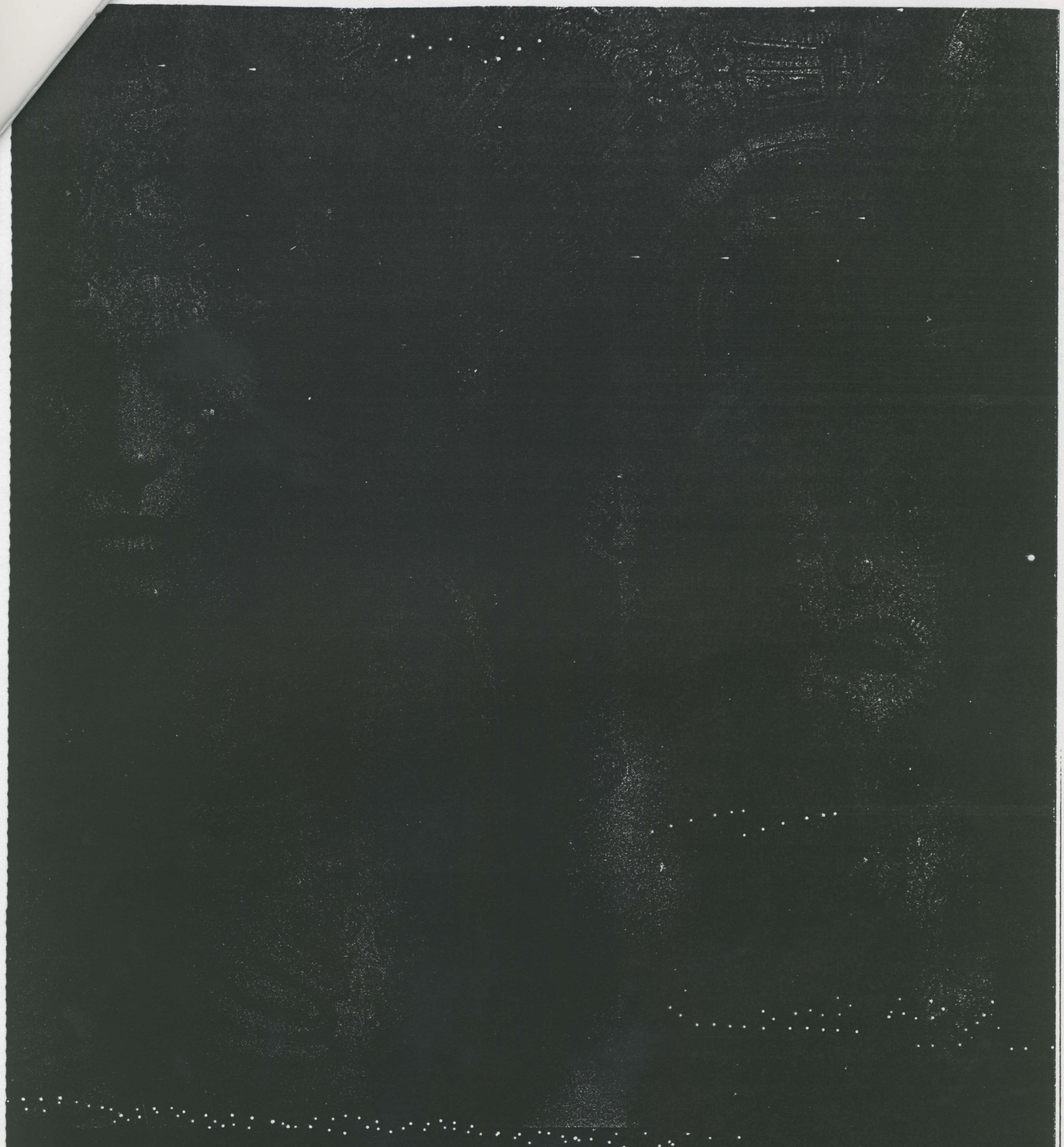


EVOLUTION'S CHILD

In a million years, the world will become the dominion of a superrace of children

BY PAMELA WEINTRAUB



They have been scouring the desert for weeks when they discover the skull.
The elements have pounded the jawbone
to pale white shards, but much of the dome remains intact. They take it
back to their desert lab to glue it together,
and when they finish they are stunned by the immensity of their find.

PAINTING BY DI MACCIO

The parched and crumbling desert lies on the eastern edge of a landmass once called North America. The earlier inhabitants, the researchers believe, were erect-walking creatures some six feet tall. Examining the skull, they calculate that these ancient men had brains half the size of theirs, with twice the jaw, and 36 teeth to their own 28. This skull, the hefty explorers conclude with rapture, belonged to their puny ancestor *Homo sapiens*, by now a million years gone.

The explorers in this scenario, with bald bulging heads and slitlike mouths, fit our twentieth-century notion of aliens from space. But if some of today's anthropologists and paleontologists are correct, they will be mankind's descendants a million years hence. They will live twice as long as we do, and their years of extra development will provide them with a greatly expanded cortex and the intellect to match. Their spectacular ascent will be achieved through *neoteny*, the same process that helped us evolve from the apes.

Neoteny is the biological mechanism that allows some species to retain infantile, or neonatal, traits throughout adult life. The idea that it might be a controlling force in *human* evolution was first suggested in the Twenties by Dutch anatomist Louis Bolk. Bolk observed that both adult humans and baby apes have small jaws, relatively large brains—about one fiftieth the weight of the body—and the ability to walk erect. Grown-up apes, on the other hand, have large jaws, relatively small brains—about one hundredth the weight of the body—and a four-legged gait. Bolk theorized that apes and the ancestors of humans had originally developed in similar ways, but in the course of evolution, the pace of human development simply slowed. The result: Men and women were perpetual neonates, never reaching the small-headed, four-legged "maturity" of apes.

As far as Bolk was concerned, neoteny had provided humankind with extraordinary evolutionary strength. By endowing successive generations with the most powerful juvenile feature—a brain that is large in comparison to the body—the neoteny mechanism had slowly turned our sedentary, apelike ancestor into the most mobile, innovative, and successful creature on Earth. The large-brained juvenile, Bolk declared, had dominion over all.

Bolk's theory received widespread support during the Sixties and Seventies, when paleontologists began excavating bones in the sweltering African plains where humanity evolved. Their discoveries showed that with each step in human evolution, the latest species always had larger heads—making it, in effect, more "childlike"—than the species that came before. The cranium, the researchers asserted, had started to expand millions of years ago, when our apelike ancestors moved out onto the open savanna. Without the protection of trees, their survival *depended* on increasingly complex brains to design tools, as well as an upright stance that left the hands free for toting objects.

Still, until recently scientists dismissed the idea that neoteny would be a major force in *future* evolution. In fact, most believed that in the centuries to come, any kind of human evolution would be insignificant. Some researchers acknowledged that nature was still refining the knee joint or increasing resistance to disease; others admitted that genetic engineering might one day allow future man to eradicate cancer, improve eyesight, and sharpen hearing. But for the most part, experts argued, human evolution had ceased. A species, they explained, evolves only when pressured to change by its environment. And as civilization eased the rigors of survival, evolutionary pressure on the human animal had come to a halt.

In the past few years, however, researchers such as New York University paleontologist Noel Boaz have rebelled against that point of view. Tall and rugged,

"Boaz believes that a million years from now, the human head will be as much as one fifth the length of the body—the same ratio as that of six-year-olds today."

looking more than a little like Indiana Jones in *Raiders of the Lost Ark*, Boaz started seeking the origins of man during his Berkeley grad-school days in the early Seventies. In 1974 and again in 1981 he explored the heart of Africa in search of bones that would shed light on man's beginnings. This year he has left for Lake Amin, Zaire, to search for the missing link—the common ancestor to both man and the apes. His excursions into the past, he says, have convinced him that "people will continue to evolve just as they always have—according to trends already in place.

"Two million years ago," Boaz explains, "our ancestors had a cranial [brain] capacity of eight hundred cubic centimeters; a million years ago they were up to twelve hundred fifty cubic centimeters; today, perhaps fifteen hundred cubic centimeters. If you extrapolate the line on a graph, you'll see the brain growing to about twenty-five hundred cubic centimeters a million years from now. There's no reason why that line should taper off."

Boaz's prediction stems from his belief that, contrary to prevailing opinion, environmental pressures have become more stringent than ever. "The new driving force in evolution," Boaz contends, "is the increase in the complexity of life. Hunters and gatherers had to find food and shelter, and that was hard. But today the problems are multiplied. Everyone has enormous options, and those who can't negotiate the diversity succumb to breakdown, schizophrenia, depression, suicide. It's obvious that these people aren't as likely to reproduce. To avoid such calamitous outcomes, we have to have a certain kind of smarts—the kind that may well come with increasingly larger, more neotenic brains."

Today the adult human head is one eighth the length of the body, but Boaz believes that, thanks to neoteny, a million years from now it will be as much as one fifth the length of the body—the same head-to-body ratio as that of contemporary six-year-olds. The human jaw, he adds, would have more or less receded under the face "because with such a large head, something has to give." Boaz acknowledges that it would be difficult to move or support such a head but explains that all we need do is develop muscles and ligaments around the neck. Since the brain consumes about 25 percent of the body's metabolic energy, a larger brain could require a larger body to provide it with food. That might well be accomplished by increasing overall body height to perhaps seven feet. Some people, he adds, say bigger-headed babies would crush the mother's pelvis, but the answer to that would be premature birth. Presumably, neonatal medicine would protect future babies born before term.

Boaz's beliefs are speculation, based largely on fieldwork and discussions with his students. But according to his colleagues, a considerable body of research supports his ideas.

Some of that research comes from Dale Russell, a paleontologist at the Canadian National Museum of Natural Sciences, in Ottawa. Russell is best known for his model of the dinosauroid—a large-brained, humanoid reptile that might have evolved by now if the dinosaurs had not become extinct (see "Smart Dinosaurs," April 1982). When Russell unveiled his full-scale, four-foot five-inch dinosauroid in 1981, it thrust him into the international limelight. It also suggested an intriguing possibility: If the size of the dinosaur's brain could increase so drastically over time, wouldn't the same be possible for other species, including modern man?

Russell felt sure the answer was yes, and he set out to substantiate the idea by studying the increase in biological complexity over the millennia. Referring to the fossil record, he found that the size of animals and plants, the total number of species on Earth, *and* the size of brains had increased through the course of evolution.

"Some dinosaurs had pretty big brains when mammalian brains were still small," Russell explains. "Yet when the dinosaurs were eliminated, average brain size didn't go down. Instead, the mammals took over

CONTINUED ON PAGE 102

CHILD

CONTINUED FROM PAGE 88

where the dinosaurs left off. Intelligence kept increasing at an ever-accelerating pace. The original actors, the dinosaurs, were replaced by a second string of actors, the mammals, who continued the old drama and haven't finished yet."

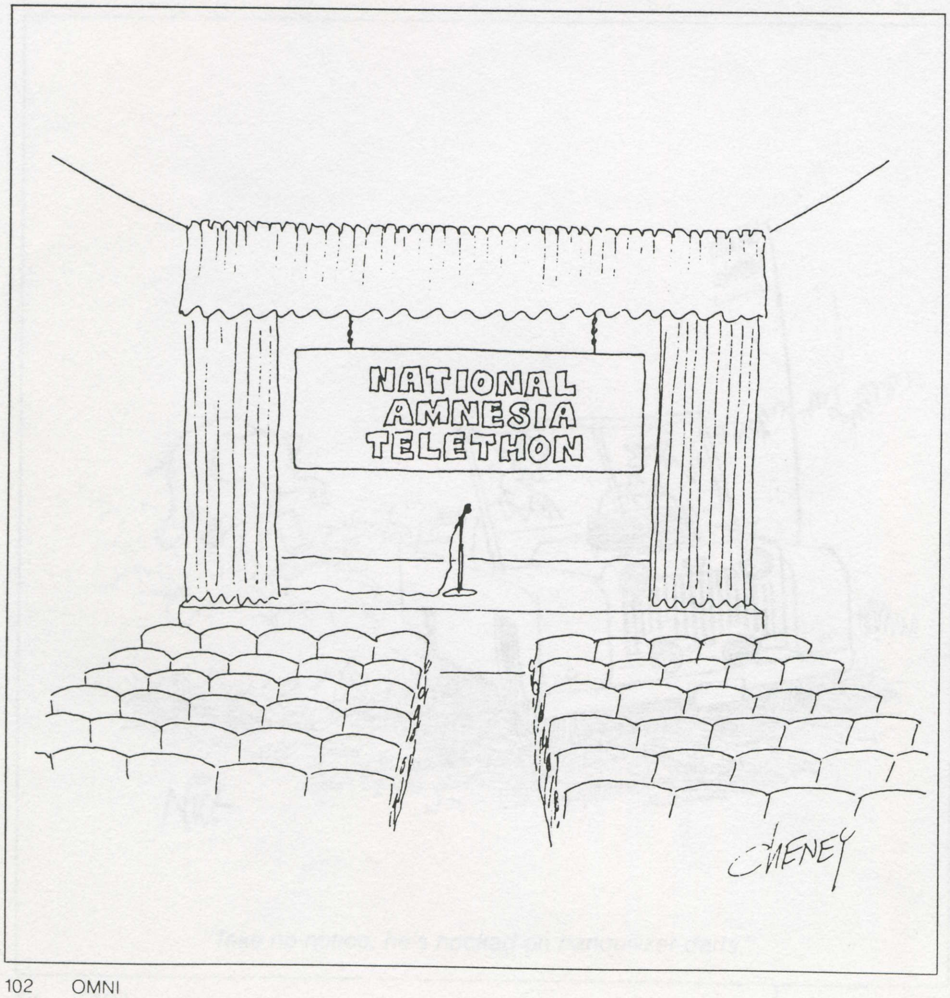
Whether you're talking about dinosaurs or mammals, Russell notes, a single biological species has never lasted more than several million years. Yet, brain size has increased steadily, despite the replacement of old species by the new. Humans as we know them aren't likely to last any longer than other species, he adds. "But from what we know about the evolution of complexity, I see no obvious impediments to humans' giving rise to another species, one that is still more highly evolved. If humans follow the pattern seen in the evolution of other organisms, that new species could be a humanoid creature with a larger, more complex brain."

The possible facial features of Russell's large-brained creature have recently been suggested by Robert Shaw, of the University of Connecticut at Storrs. Shaw's work with computer graphics shows that if the human brain grows larger, the corresponding face will have the neotenic traits—round cheeks, small lips, receding jaw—that were predicted by Boaz.

Shaw, a cognitive psychologist, began studying the human face to learn what features our eyes latch onto when we recognize a friend. "To do that," Shaw relates, "I had to determine the crucial components of the face. That meant learning just what a face is and exactly how it develops. I thought the best way to study all the elements would be to watch faces generated on a computer screen."

Shaw went on to create a computer program describing how the human face develops from birth to adulthood (about the age of twenty). Proceeding on the theory that growing facial bones were influenced primarily by the force of gravity, he found that if he started with the face of a normal baby, then applied his special gravity model, the computer face always retraced human development in a matter of seconds. As the white-lined profile on his screen went from infancy to adolescence, the cranium shrank, the forehead narrowed, and the jaw expanded. The program, it turned out, described facial growth better than any other.

One day, on a lark, Shaw and co-workers (including John Pittenger, Jim Todd, and Leonard Mark) instructed the face on the computer to keep developing beyond the age of twenty, when human-bone growth usually comes to a halt. Says Shaw: "We thought that by telling the computer to push bone growth beyond the point of complete maturity, we'd generate some kind of monster. But to our surprise, the face became increasingly primitive. It took a few minutes for me to realize we were generating images of our ancestors. Instead of mimicking aging, the program was now going back through what seemed like the stages of evolution. In essence, it was portraying what might be called *devolution*. The twenty-year-old *Homo sapiens* turned into an individual resembling our ancestor *Homo erectus* and then into a humanlike creature more primitive than that."



The program's ability to retrace evolution, Shaw thought, was explained if one defined evolution as growth that occurs over eons. If devolution could be simulated by excess maturity, he reckoned, it might be possible to simulate future evolution by making the image increasingly immature. To do that, he started with the image of an ordinary *Homo sapiens* infant and told the computer to make it younger and younger. He entered the appropriate equations, and to his amazement the infant's forehead bulged and the jaw receded until it was tucked behind the nose. "It resembled your typical extraterrestrial: big brain, big eyes, and all," he recalls. "The suggestion was that evolution might create large-brained, baby-faced adults."

In his next experiments, Shaw went on to demonstrate just why these baby-faced adults would be likely to evolve. First, Shaw and his student, Thomas Alley, used the computer program to create pictures of children with a wide range of head and face proportions. The result: Human subjects viewing the pictures reported a protective response toward children with larger foreheads, rounder faces, and smaller jaws—children who looked younger for their age. Then Shaw's associate, Viki McCabe, who examined pictures from the Los Angeles County sheriff's department, found that battered children were usually more adult looking than their well-protected siblings. The disturbing implication: Neotenic-looking children inspire more tenderness and thus have an evolutionary advantage, even today. If natural selection is in fact a force to be reckoned with, then neoteny's child will probably be the one most likely to survive.

Before the juvenile inherit the earth they'll need at least a million years to complete their evolutionary odyssey, unless scientists learn enough about the process to create the new species ahead of time.

One man who can't see waiting for evolution to unwind is anthropologist William Chmerny, of Idaho State University. Chmerny became fascinated by neoteny as a graduate student in anthropology, when he "had more trouble mastering Spanish than a mere child would have." Chmerny realized that children absorbed not just a second language, but even a third or a fourth with ease. It dawned on him that geniuses like Mozart and Einstein had produced their major work before the age of thirty, when the brain is still developing. What's more, he recalls, "I knew that children had six or seven times more dream sleep than adults, giving them extra hours to make sense of all the data they absorbed during the day."

Chmerny's observations convinced him that if he could render the brain permanently "childlike"—creative, intuitive, and rich in dreams—human intelligence would know no bounds. After years of studying evolution, he felt he might best achieve this end by artificially accelerating neoteny. Before he could attempt such a thing, though, he had to know a lot more about how neoteny worked.

His biggest clue to the mechanism came in 1974, when California paleontologist Donald Johanson found the three- to four-million-year-old skeleton of the protohuman Lucy. The amazing thing about Lucy was that she'd walked erect, evolving from her four-legged predecessors in less than a million years. A million years, Chmerny knew, was a blink of geologic time, normally long enough for only about 250 genes to mutate. Yet the essential changes in Lucy's brain, muscles, and bones should have required millions of genetic mutations, and thus many millions of years.

Chmerny faced a paradox, but his avid interest in neoteny quickly presented a solution. He knew, first of all, that the juvenile form of Lucy's four-legged ancestor had probably walked erect, just as baby apes do today. Suppose, he theorized, that only those specific genes capable of arresting development—the genes of neoteny—had changed, causing the adult Lucy and her kin to retain the juvenile capability for bipedal walking. If that were the case, the change from quadrupedal to bipedal walking *could* be accomplished with a couple of hundred gene changes instead of a couple of million.

To pin down the point of change from four- to two-legged walking—the first major neoteny event in the evolution of man—Chmerny is now examining human and chimpanzee fetuses. Until about three months after conception, Chmerny explains, both species seem to be developing the anatomical architecture for bipedal walking. But sometime after the three-month mark the chimp fetus starts developing the anatomy for quadrupedal walking while the human maintains its immature, bipedal form.

These different developmental paths, Chmerny believes, can be traced to the production of still-unidentified body proteins. In both chimps and humans, his theory goes, the genes producing proteins for the juvenile, or bipedal, anatomy turn on and off at much the same pace. But in chimps, the next set of genes—those producing proteins for the quadrupedal form—take over within about three months; in humans these genes are repressed.

By studying development in the fetuses of humans and chimps, Chmerny hopes to identify the various proteins involved. Then he'll use recombinant-DNA technology to find the genes that produce those proteins. Since both bipedalism and intelligence seem to have emerged through neoteny, he adds, similar techniques may help us find both sets of genes.

"When we find those genes," he concludes, "we won't have to wait for neoteny to increase the juvenile proteins. We'll alter the genes ourselves through recombinant-DNA technology, letting sexual maturity progress to completion but keeping part of the brain, especially the cerebral cortex, immature. Thus," he concludes, "we'll have the best of both worlds: an adult body combined with an essentially adult brain that has retained the curiosity, creativity, and insight of the child."

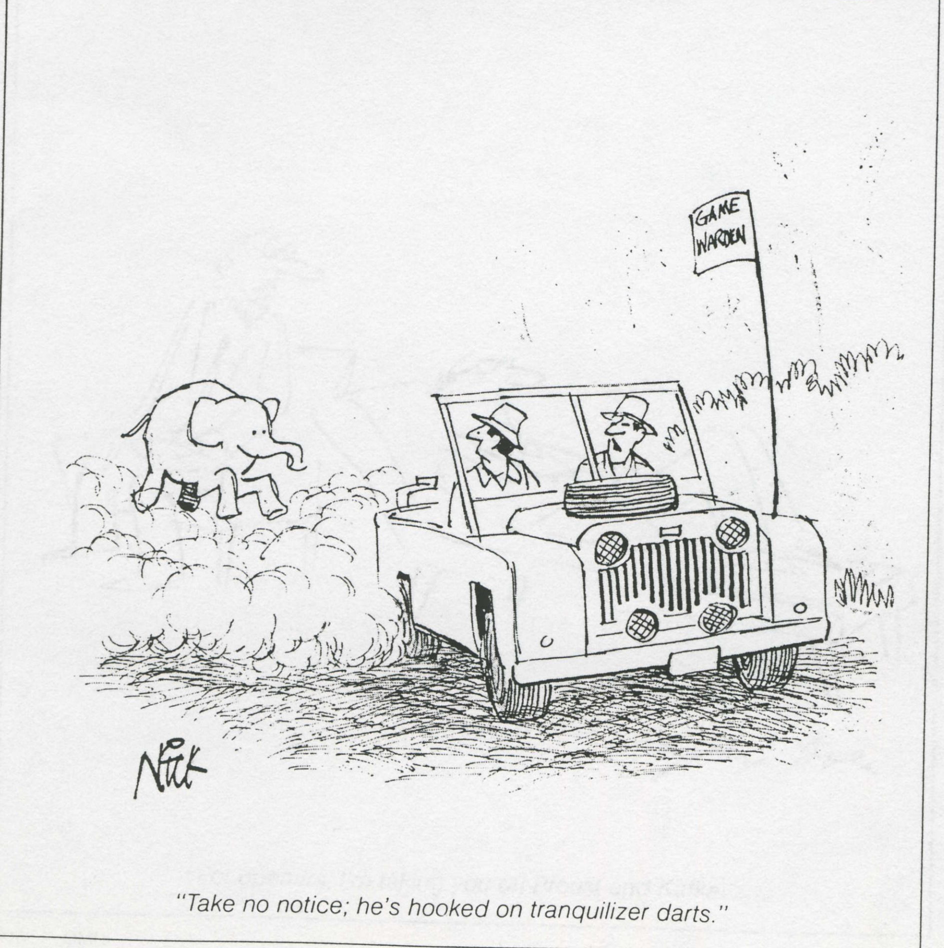
Does Chmerny see any ethical problems with redesigning twentieth-century humans? "Yes," he says. "The principal danger has to do with what you're redesigning them for. I certainly wouldn't want to make better soldiers or better political subjects. But if we could expand human potential instead of limiting it, then the concept of genetically engineering humans is one I would support."

Though Chmerny still hasn't located the genes that control neoteny, another expert, gerontologist Richard Cutler, has an idea where they are. Cutler was propelled to the study of neoteny through his lifelong desire to understand and expand human longevity. Brought up in a religious home, he was taught from birth that he'd be rewarded with immortality if he were good. But once he started studying science and evolution, he began to suspect that no matter how good he was, death was something he couldn't avoid. "The reality of a finite human life span," he says, "has been with me ever since.

"After a while," he adds, "I realized that I'd still be in school at the age of thirty, and that I wouldn't even begin my scientific career until after I reached my biological and intellectual prime. I'd always been interested in space travel, but it seemed foolish to spend all that money getting to other planets if we had a limited life span. I reasoned that increasing life span was the first order of business. In the long term, scientific discovery would be far more advanced if scientists had just a five or ten percent increase in health and vigor."

Determined to break the life-span bottleneck, Cutler began his graduate training at Brookhaven National Laboratory, in Upton, New York. Burying himself in books, he soon learned a simple rule of thumb: A species' life span always increased as its brain size increased. Since the human brain had clearly gotten larger in the course of evolution, Cutler concluded, "it didn't seem likely that we'd come from long-lived ancestors like Methuselah. Human life span had not decreased through the millennia, but rather, must have increased at an ever-quickening pace."

Because the increase in brain size and life span had been so rapid, Cutler, like



"Take no notice; he's hooked on tranquilizer darts."

Chmerny, believed that no more than a couple of hundred genes were involved in neoteny and hominid evolution as a whole. As generations passed, he theorized, these relatively few genes had begun to work overtime, stretching out every stage of development, from childhood to puberty to the years of decline. Because development slowed, brains had more time to grow larger, and adults came to resemble the children of their ancestors. To Cutler this made exquisite sense. If a large-brained creature had a longer childhood, he'd have more prime years to explore and learn. With a longer period of adulthood, he'd have more time to refine and apply that knowledge. Hence, neotenic individuals with larger brains and longer life spans would have a better chance for survival; their progeny would always prevail.

Cutler began a serious quest for the neoteny genes at Baltimore's Gerontology Research Center in 1976. There, with his wife serving as lab technician, he developed his plan of attack.

Aging, he reasoned, was instigated by advancing stages of physical development, but it also took place day-to-day because of toxic particles released as the body metabolized food and oxygen. Dozens of natural enzymes, Cutler knew, protected the body against these poisonous particles, and humans, with their long life spans, had more of these enzymes than other mammals. In fact, by comparing humans with twelve primate species, he calculated that the enzymes had increased in direct proportion to advancing neoteny. The connection was so striking, in fact, that the antitoxin genes and the genes of neoteny seemed to be in some way connected. Cutler even thought they might literally be strung together, forming one huge neoteny supergene coding for upright posture, longevity, and intelligence.

Cutler's dream is doubling or tripling life span by altering the genes of neoteny. The neoteny gene group, he feels, probably encompasses the DNA coding for the antitoxin enzymes. Thus, if he can locate the antitoxin genes (possible through years of work with recombinant-DNA technology) he feels he may find the neoteny genes coding for longevity and brain size as well. Altering those genes in a fertilized human egg, Cutler adds, would be tantamount to creating future man.

Though Cutler concedes that such a task might take centuries, he's already sketched a version of our human descendant, *Homo sapiens futurus*, based on his work in the lab. When the crucial genes are altered, he explains, futurus will be born after a nine-month gestation, his head-to-body ratio somewhat greater than the infant's of today. He'll reach sexual maturity at twenty-eight and grow until age forty, when he'll have a head twice the size of ours. He'll also have a taller frame to support his mammoth brain. He'll reach middle age at sixty and die at perhaps two hundred.

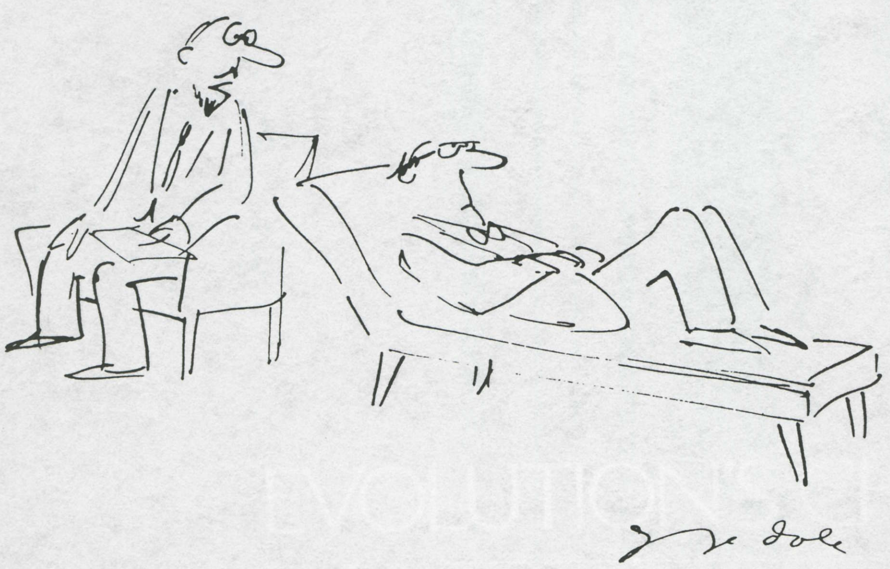
Discussing his drawing from the din of his lab, a centrifuge whirring in the corner, Cutler says he sees no specific physiological limit to the increase in neoteny. "We don't yet know," he explains, "to what extent futurus might evolve before a biological restriction is reached. He might easily surpass the two-hundred-year life span and twenty-eight-hundred-cubic-centimeter brain we're discussing today."

Our future as neonate, of course, is hardly etched in stone. Anthropologist C. Owen Lovejoy, of Kent State University, in Ohio, says that although neoteny is one possible evolutionary path, he doesn't see mankind moving in that direction. "Evolution occurs only when those with a particular trait have more offspring than those without it," Lovejoy contends. "I don't see people with greater intelligence having more children. So where's the natural force leading to greater intelligence? As for life span, most people have children before forty no matter how long they live. So unless we intervene, we'll have no particular selection for longevity, either."

Another critic, Jonas Salk (of polio-vaccine fame), believes that the urge to create futurus on our own is misguided. "I don't really see the need for that kind of advancement," says Salk, who's been studying human evolution since the late Sixties. "Even if these genes could be altered and then transferred to a number of individuals, we would still have to rely on the slow process of biological evolution to transform the species. For instance, here at the Salk Institute we created a giant mouse by giving it genes for rat growth hormone. Right now we're waiting to see whether this trait will carry over to succeeding generations. But whether or not it does, I daresay there are mice in the world that will pay absolutely no attention to what goes on here. If we wish to contribute to human evolution, we can do it far more efficiently by improving the state of the world."

Cutler, however, disagrees. "Only a very stupid person would claim we were intelligent and long-lived enough," he says. "People are always saying that if we lived much longer, Social Security would be destroyed, or we'd have more divorces. They think if you want to change our brains and our life span you've got to be a bit screwy. But longevity and intelligence evolved naturally in humans; they are the traits that separate us from the animals. Increased life span and intelligence are part of our heritage, and to me it makes sense that using technology to create more of the same would be even better."

Cutler concludes his speech and rises, anticipating an afternoon in the lab. The discussion has made him flush, but the glow only highlights his thick white hair. He is forty-seven, and as a *Homo sapiens*, his life is more than half complete. But if his ideas are correct, they might buy a bit more time for his descendants, *Homo sapiens futurus*, the new race of man. ∞



"For openers, I'm taking you off Proust and Kafka."