A Matter of Degree

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In *Alexander's Feast,* John Dryden describes his hero, besotted after dinner, retelling the tales of his martial glory:

> The King grew vain;
> Fought all his battles o'er again;
> And thrice he routed all his foes,
> and thrice he slew the slain.

One hundred and fifty years later, Thomas Henry Huxley invoked the same image in declining to pursue further the decisive victory he had won over Richard Owen in the great hippocampus debate: "Life is too short to occupy oneself with the slaying of the slain more than once."

Owen had sought to establish our uniqueness by arguing that a small convolution of the human brain, the hippocampus minor, was absent in chimps and gorillas (and all other creatures), but present in *Homo sapiens* alone. Huxley, who had been dissecting primates while preparing his seminal work, *Evidence as to Man's Place in Nature,* showed conclusively that all apes had a hippocampus, and that any discontinuity in the structure of primate brains lay between prosimians (lemurs and tarsiers) and all other primates (including humans), not between man and the great apes. Yet for a month, in April, 1861, all England watched as her two greatest anatomists waged war over a little bump on the brain. *Punch* laughed and versified; and Charles Kingsley wrote at length of the "hippopotamus major" in his children's classic of 1863, *The Water Babies.* If a water baby had ever been found, he commented, "they would have put it into spirits, or into the *Illustrated News,* or perhaps cut it into two halves, poor dear little thing, and sent one to Professor Owen, and one to Professor Huxley, to see what they could each say about it."

The Western world has yet to make its peace with Darwin and the implications of evolutionary theory. The hippocampus debate merely illustrates, in light relief, the greatest impediment to this reconciliation - our unwillingness to accept continuity between ourselves and nature, our ardent search for a criterion to assert our uniqueness. Again and again, the great naturalists have enunciated general theories of nature and made singular exceptions for humans. Charles Lyell envisioned a world in steady-state: no change through time in the complexity of life, with all organic designs present from the first. Yet man alone was created but a geological instant ago - a quantum jump in the moral sphere imposed upon the constancy of mere anatomical design. And Alfred Russel Wallace, an ardent selectionist who far out-Darwined Darwin in his rigid insistence on natural selection as the sole directing force for evolutionary change, made his only exception for the human brain (and turned to spiritualism late in his life). Darwin himself, although he accepted strict continuity, was reluctant to expose his heresy. In the first edition of the *Origin of Species* (1859), he wrote only that "light will be thrown on the origin of man and his history." Later editions added the intensifier "much" before the sentence, Only in 1 871 did he gather the courage to publish *The Descent of Man.*

Chimps and gorillas have long been the battleground of our search for uniqueness; for if we could establish an unambiguous distinction – of kind rather than of degree - between ourselves

and our closest relatives, we might gain the justification long sought for our cosmic arrogance. The battle shifted long ago from a simple debate about evolution: educated people now accept the evolutionary continuity between humans and apes. But we are so tied to our philosophical and religious heritage that *we* still seek a criterion for strict division between our abilities and those of chimpanzees. For, as the psalmist sang: "What is man, that thou art mindful of him? .. For thou has made him a little lower than the angels, and hast crowned him with glory and honor." Many criteria have been tried, and, one by one they have failed. The only honest alternative is to admit the strict continuity in kind between ourselves and chimpanzees. And what do we lose thereby? Only an antiquated concept of soul to gain a more humble, even exalting vision of our oneness with nature. I propose to examine three criteria for distinction and to argue that, on al1 accounts, we are more nearly akin to the chimpanzee than even Huxley dared to think.

1. Morphological uniqueness in the Owenian tradition, Huxley permanently dimmed the ardor of those seeking an anatomical discontinuity between humans and apes. Still, the search has continued in some quarters. The differences between adult chimps and people are not trifling, but they do not arise from any difference in kind. Part by part, order by order, *we* are the same; only relative sizes and rates of growth differ. With the painstaking attention to detail so characteristic of German anatomical research, Prof, D. Starck and his colleagues have recently concluded that differences between the skulls of humans and chimps are quantitative only.

2. Conceptual uniqueness. Few scientists have strongly pushed the anatomical argument since Owen's debacle. Instead, the defenders of human uniqueness have posited an unbridgeable chasm between the mental abilities of humans and chimps. To illustrate the gap, they have sought an unambiguous criterion of distinction. An earlier generation cited use of tools, but clever chimps employ all sorts of artifacts to reach inaccessible bananas or release imprisoned mates.

More recent claims have centered on language and conceptualization, the last bastion for potential differences in kind. Early experiments on teaching chimps to talk were notably unsuccessful - a few grunts and a trifling vocabulary. Some concluded that the failure must reflect a deficiency in cerebral organization, but the explanation seems simpler and far less profound (although by no means unimportant for what it implies about the linguistic capabilities of chimps in natural conditions): the vocal cords of chimpanzees are constructed in such a way that large repertories of articulated sounds cannot be produced. If we could only discover a different way of communicating with them, we might find that chimps are much smarter than we think.

By now, all readers of newspapers and watchers of television have learned of the striking initial successes of another way - communicating with chimps via sign language of the deaf and dumb. When Lana, star pupil of the Yerkes Laboratory, began to ask for the names of objects she had not previously seen, can we any longer deny to chimps the capacity to conceptualize and to abstract? This is no mere Pavlovian conditioning. In February, 1975, R. A. and B. T. Gardner reported their first results on two baby chimpanzees raised with sign language from the day of their birth. (Washoe, their previous subject, was not exposed to sign language until she was a year old. After six months of training, her vocabulary consisted of only two signs.) Both baby chimps began to make recognizable signs in their third month. One, Moja, had a four-word vocabulary in her thirteenth week: come-gimme, go, more, and drink. Their current progress is no slower than that of a human child (we generally wait for words and do not realize that our babies signal us in other ways long before they speak). Of course, I do not believe that our mental differences with chimps are merely a question of

nurturing. I have no doubt that the progress of these baby chimps will slow down relative to the growing achievements of human babies. The next president of our country will not belong to another species. Still, the Gardners' work is a striking demonstration of how we have underestimated our closest biological relatives.

3 . Overall genetic differences. Even if we admit that no single feature or ability completely separates humans and chimps, at least we might be able to affirm that the overall genetic differences between us are tolerably great. After all, the two species look very different and do very different things under natural conditions. (For all the quasi-linguistic capacity shown by chimps in the laboratory, we have no evidence of rich conceptual communication in the wild.) But Mary-Claire King and A, C. Wilson have recently published an account of genetic differences between the two species *(Science,* April 11, 1975), and the results may well upset a prior prejudice still carried, I suspect, by most of us. In short, using all the-biochemical techniques now available and surveying as many proteins as possible, the overall genetic differences are remarkably small.

When two species scarcely differ in morphology but function as separate and reproductively isolated populations in nature, evolutionary biologists speak of "sibling species." Sibling species generally display far fewer genetic differences than pairs of species placed in the same genus but clearly different in morphology ("congeneric species"). Now chimps and humans are obviously not sibling species; we are not even congeneric species by conventional taxonomic practice (chimps belong to the genus *Pan;* we are *Homo sapien).* But King and Wilson have shown that the overall genetic distance between humans and chimps is less than the average for sibling species and far less than in any tested pair of congeneric species.
A fine paradox, for although I have argued strongly that our distinctions are matters of degree only, we are still very different animals. If the overall genetic distance is so small, then what has caused such a divergence in form and behavior? Under the atomistic notion that each organic trait is controlled by a single gene, we cannot reconcile our anatomical dissimilarities with King and Wilson's findings, for many differences in form and function would have to reflect many differences in genes.

The answer must be that certain kinds of genes have far reaching effects-they must influence the entire organism, not just single traits. A few changes in these key genes might produce a great divergence between two species without much overall genetic differentiation. King and Wilson therefore seek to resolve the paradox by attributing our differences from chimps primarily to mutations of the regulatory system.

Liver cells and brain cells have all the same chromosomes and all the same genes. Their profound difference does not arise from genetic constitution, but from alternate paths of development. During development, different genes must be turned on and off at different times in order to achieve such disparate results from the same genetic system. In fact, the whole mysterious process of embryology must be regulated by exquisite timing in the action of genes. To differentiate a band from a homogeneous limb bud, for example, cells must proliferate in some areas (destined to be fingers) and die in others (the spaces between them). Much of the genetic system must be devoted to setting the timing of these events - to turning genes on and off - rather than to the determination of specific trait. We refer to genes that control the timing of developmental events as the regulatory system. Clearly, change in a single regulatory gene can have profound effects upon the entire organism. Delay or accelerate a key event in embryology and the whole course of future development may be

changed. King and Wilson therefore suppose that the primary genetic differences between humans and chimps lie in this all-important regulatory system.

This is a reasonable (even necessary) hypothesis. But do we know anything about the nature of this regulatory difference? We cannot now identify the specific genes involved; hence, King and Wilson express no opinion. "Most important for the future study of human evolution," they write, "would be the demonstration of differences between apes and humans in the timing of gene expression during development." But I believe that we do know the basis of this change in timing. As I argue in essay 7, *Homo sapiens* is basically a neotenic species; we have evolved from apelike ancestors by a general retardation in developmental rate. We should look for regulatory changes that slow down the ontogenetic trends we share with all primates and allow us to retain juvenile growth tendencies and proportions.

The very small genetic distance between humans and chimps might tempt us to try the most potentially interesting and ethically unacceptable scientific experiment I can imagine - to hybridize our two species and simply to ask the offspring what it is like to be, at least in part, a chimpanzee. This interbreeding may well be possible so small are the genetic distances that separate us. But, lest we fear the rise of a race comparable to the heroes in Planet of the Apes, I hasten to add that the hybrids would almost certainly be sterile - like a mule, and for the same reason. The genetic differences between humans and chimps are minor, but they include at least ten large inversions and translocations. An inversion is, literally, the turning around of a chromosomal segment. Each hybrid cell would have a set of chimp and a corresponding set of human chromosomes. Egg and sperm cells are made by a process called meiosis, or reduction division. In meiosis, each chromosome must pair (lie side by side) with its counterpart before cell division, so that corresponding genes can match up one to one: that is, each chimp chromosome must pair with its human counterpart. But if a piece of human chromosome is inverted relative to its counterpart in chimps, then gene-by-gene pairing cannot occur without elaborate looping and twisting that usually precludes successful cell division. The temptations are great, but I trust that this pairing will remain on the index of forbidden experiments. The temptation, in any case, will surely diminish as we discover how to talk with our closest relatives. I am beginning to suspect that we will learn everything we want to know directly from the chimps themselves.