THE THIRD CHIMPANZEE

The Evolution and Future OF THE *Human Animal*

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CHAPTER 1

A Tale of Three Chimps

THE NEXT TIME YOU VISIT A ZOO, MAKE A POINT OF WALKING PAST the ape cages. Imagine that the apes had lost most of their hair, and imagine a cage nearby holding some unfortunate people who had no clothes and couldn't speak but were otherwise normal. Now try guessing how similar those apes are to us in their genes. For instance, would you guess that a chimpanzee shares 10 percent, 50 percent, or 99 percent of its genetic program with humans?

Then ask yourself why those apes are on exhibit in cages, and why other apes are being used for medical experiments, while it's not permissible to do either of those things to humans. Suppose it turned out that chimp genes were 99.9 percent identical to our genes, and that the important differences between humans and chimps were due to just a few genes. Would you still think it's okay to put chimps in cages and to experiment on them? Consider those unfortunate mentally defective people who have much less capacity to solve problems, to care for themselves, to communicate, to engage in social relationships, and to feel pain than do apes. What is the logic that forbids medical experiments on those people, but not on apes?

You might answer that apes are "animals," while humans are humans, and that's enough. An ethical code for treating humans shouldn't be extended to an "animal," no matter how similar its genes are to ours, and no matter what its capacity for social relationships or feeling pain. That's an arbitrary but at least self-consistent answer that can't be lightly dismissed. In that case, learning more about our ancestral relationships won't have any ethical consequences, but it will still satisfy our intellectual curiosity to understand where we come from. Every human society has felt a deep need to make sense of its origins, and has answered that need with its own story of the Creation. The Tale of Three Chimps is the Creation Story of our time.

FOR CENTURIES it's been clear approximately where we fit into the animal kingdom. We are obviously mammals, the group of animals characterized by having hair, nursing their young, and other features. Among mammals we are obviously primates, the group of mammals including monkeys and apes. We share with other primates numerous traits lacking in most other mammals, such as flat fingernails and toenails rather than claws, hands for gripping, a thumb that can be opposed to the other four fingers, and a penis that hangs free rather than being attached to the abdomen. Already by the second century A.D., the Greek physician Galen deduced our approximate place in nature correctly when he dissected various animals and found that a monkey was "most similar to man in viscera, muscles, arteries, veins, nerves, and in the form of bones."

It's also easy to place us within the primates, among which we are obviously more similar to apes (the gibbons, orangutan, gorilla, and chimpanzees) than to monkeys. To name only one of the most visible signs, monkeys sport tails, which we lack along with apes. It's also clear that gibbons, with their small size and very long arms, are the most distinctive apes, and that orangutans, chimpanzees, gorillas, and humans are all more closely related to each other than any is to gibbons. But to go further with our relationships proves unexpectedly difficult. It has provoked an intense scientific debate, which revolves around three questions:

What is the detailed family tree of relationships among humans, the living apes, and extinct ancestral apes? For example, which of the living apes is our closest relative?

When did we and that closest living relative, whichever ape it is, last share a common ancestor?

What fraction of our genetic program do we share with that closest living relative?

At first, it would seem natural to assume that comparative anatomy had already solved the first of those three questions. We look especially like chimpanzees and gorillas, but differ from them in obvious features like our larger brains, upright posture, and much less body hair, as well as in many subtler points. However, on closer examination these anatomical facts aren't decisive. Depending on what anatomical characters one considers most important and how one interprets them, biologists differ as to whether we are most closely related to the orangutan (the minority view), with chimps and gorillas having branched off our family tree before we split off from orangutans, or whether we are instead closest to chimps and gorillas (the majority view), with the ancestors of orangutans having gone their separate way earlier.

Within the majority, most biologists have thought that gorillas and chimps are more like each other than either is like us, implying that we branched off before the gorillas and chimps diverged from each other. This conclusion reflects the commonsense view that chimps and gorillas can be lumped in a category termed "apes," while we're something different. However, it's also conceivable that we look distinct only because chimps and gorillas haven't changed much since we shared a common ancestor with them, while we were changing greatly in a few important and highly visible features like upright posture and brain size. In that case, humans might be most similar to gorillas, or humans might be most similar to chimps, or humans and gorillas and chimps might be roughly equidistant from each other in overall genetic makeup.

Thus, anatomists have continued to argue about the first question, the details of our family tree. Whichever tree one prefers, anatomical studies by themselves tell us nothing about the second and third questions, our time of divergence and genetic distance from apes. Perhaps, however, fossil evidence might in principle solve the questions of the correct ancestral tree and of dating, though not the

question of genetic distance. That is, if we had abundant fossils, we might hope to find a series of dated protohuman fossils and another series of dated protochimp fossils converging on a common ancestor around ten million years ago, converging in turn on a series of protogorilla fossils twelve million years ago. Unfortunately, that hope for insight from the fossil record has also been frustrated, because almost no ape fossils of any sort have been found for the crucial relevant period between five and fourteen million years ago in Africa.

THE SOLUTION to these questions about our origins came from an unexpected direction: molecular biology as applied to bird taxonomy. About thirty years ago, molecular biologists began to realize that the chemicals of which plants and animals are composed might provide "clocks" by which to measure genetic distances and to date times of evolutionary divergence. The idea is as follows. Suppose there is some class of molecules that occurs in all species, and whose particular structure in each species is genetically determined. Suppose further that that structure changes slowly over the course of millions of years because of genetic mutations, and that the rate of change is the same in all species. Two species derived from a common ancestor would start off with identical forms of the molecule, which they inherited from that ancestor. But mutations would then occur independently and produce structural changes between the molecules of the two species. Thus, the two species' versions of the molecule would gradually diverge in structure. If we knew how many structural changes occur on the average every million years, we could then use the present difference in the molecule's structure between any two related animal species as a clock, to calculate how much time had passed since the species shared a common ancestor.

For instance, suppose one knew from fossil evidence that lions and tigers diverged five million years ago. Suppose the molecule in lions was 99 percent identical in structure to the corresponding molecule in tigers and differed only by 1 percent. If one then took a pair of species of unknown fossil history and found that the molecule differed by 3 percent between those two species, the molecular clock would say that they had diverged three times five million, or fifteen million, years ago.

Neat as this scheme sounds on paper, testing whether it succeeds in practice has cost biologists much effort. Four things had to be done

before molecular clocks could be applied: scientists had to find the best molecule; find a quick way of measuring changes in its structure; prove that the clock runs steady (i.e., that the molecule's structure really does evolve at the same rate among all species that one is studying); and measure what that rate is.

Molecular biologists solved the first two of these problems by around 1970. The best molecule proved to be deoxyribonucleic acid (abbreviated DNA), the famous substance whose structure James Watson and Francis Crick showed to consist of a double helix, thereby revolutionizing the study of genetics. DNA is made up of two complementary and extremely long chains, each made up of four types of small molecules whose sequence within the chain carries all the genetic information transmitted from parents to offspring. A quick method of measuring changes in DNA structure is to mix the DNA from two species, then measure by how many degrees of temperature the melting point of the mixed (hybrid) DNA is reduced below the melting point of pure DNA from a single species. The method is generally referred to as DNA hybridization. As it turns out, a melting point lowered by one degree centigrade (abbreviated: $\Delta T = 1^\circ C$) means that the DNAs of the two species differ by roughly 1 percent.

IN THE 1970s most molecular biologists and most taxonomists had little interest in each other's work. Among the few taxonomists who appreciated the potential power of the new DNA hybridization technique was Charles Sibley, an ornithologist then serving as Professor of Ornithology and Director at Yale's Peabody Museum of Natural History. Bird taxonomy is a difficult field because of the severe anatomical constraints imposed by flight. There are only so many ways to design a bird capable, say, of catching insects in midair, with the result that birds of similar habits tend to have very similar anatomies, whatever their ancestry. For example, American vultures look and behave much like Old World vultures, but biologists have come to realize that the former are related to storks, the latter to hawks, and that their resemblances result from their common life-style. Frustrated by the shortcomings of traditional methods for deciphering bird relationships, Sibley and Jon Ahlquist turned in 1973 to the DNA clock, in the most massive application to date of the methods

of molecular biology to taxonomy. Not until 1980 were Sibley and Ahlquist ready to begin publishing their results, which eventually came to encompass applying the DNA clock to about seventeen hundred bird species—nearly one-fifth of all living birds.

While Sibley's and Ahlquist's achievement was a monumental one, it initially caused much controversy because so few other scientists possessed the mixture of expertises required to understand it. Here are typical reactions I heard from my scientist friends:

"I'm sick of hearing about that stuff. I no longer pay attention to anything those guys write." (An anatomist.)

"Their methods are okay, but why would anyone want to do something so boring as all that bird taxonomy?" (A molecular biologist.)

"Interesting, but their conclusions need a lot of testing by other methods before we can believe them." (An evolutionary biologist.)

"Their results are the Revealed Truth, and you better believe it." (A geneticist.)

My own assessment is that the last view will prove to be the most nearly correct one. The principles on which the DNA clock rests are unassailable; the methods used by Sibley and Ahlquist are state-of-the-art; and the internal consistency of their genetic distance measures from over eighteen thousand hybrid pairs of bird DNA testifies to the validity of their results.

Just as Darwin had the good sense to marshal his evidence for variation in barnacles before discussing the explosive subject of human variation, Sibley and Ahlquist similarly stuck to birds for most of the first decade of their work with the DNA clock. Not until 1984 did they publish their first conclusions from applying the same DNA methods to human origins, and they refined their conclusions in later papers. Their study was based on DNA from humans and from all of our closest relatives: the common chimpanzee, pygmy chimpanzee, gorilla, orangutan, two species of gibbons, and seven species of Old World monkeys. Figure 1 summarizes the results.

As any anatomist would have predicted, the biggest genetic difference, expressed in a big DNA melting-point lowering, is between monkey DNA and the DNA of humans or of any ape. This simply puts a number on what everybody has agreed ever since apes first became known to science: that humans and apes are more closely related to each other than either are to monkeys. The actual number

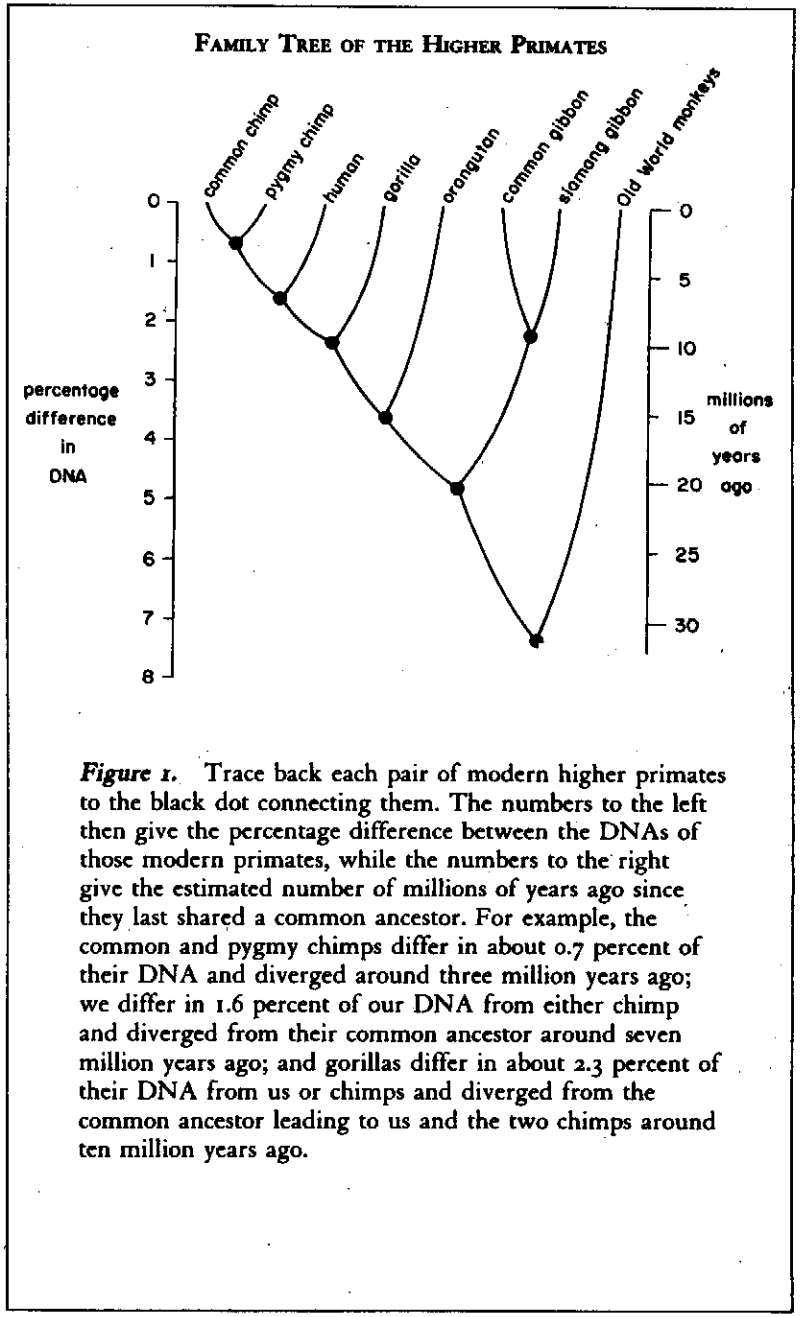

Figure 1. Trace back each pair of modern higher primates to the black dot connecting them. The numbers to the left then give the percentage difference between the DNAs of those modern primates, while the numbers to the right give the estimated number of millions of years ago since they last shared a common ancestor. For example, the common and pygmy chimps differ in about 0.7 percent of their DNA and diverged around three million years ago; we differ in 1.6 percent of our DNA from either chimp and diverged from their common ancestor around seven million years ago; and gorillas differ in about 2.3 percent of their DNA from us or chimps and diverged from the common ancestor leading to us and the two chimps around ten million years ago.

is that monkeys share 93 percent of their DNA structure with humans and apes, and differ in 7 percent.

Equally unsurprising is the next-biggest difference, one of 5 percent between gibbon DNA and DNA of other apes or humans. This too confirms the accepted view that gibbons are the most distinct apes, and that our affinities are instead with gorillas, chimpanzees, and orangutans. Among those latter three groups of apes, most recent anatomists have considered the orangutan as somewhat separate, and that conclusion too fits the DNA evidence: a difference of 3.6 percent between orangutan DNA and that of humans, gorillas, or chimpanzees. Geography confirms that the latter three species parted from gibbons and orangutans quite some time ago: living and fossil gibbons and orangutans are confined to Southeast Asia, while living gorillas and chimpanzees plus early fossil humans are confined to Africa.

At the opposite extreme but equally unsurprising, the most similar DNAs are those of common chimpanzees and pygmy chimpanzees, which are 99.3 percent identical and differ by only 0.7 percent. So similar are these two chimp species in appearance that it was not until 1929 that anatomists even bothered to give them separate names. Chimps living on the equator in central Zaire rate the name "pygmy chimps" because they average slightly smaller (and have more slender builds and longer legs) than the widespread "common chimps" ranging across Africa just north of the equator. However, with the increased knowledge of chimp behavior acquired in recent years, it has become clear that the modest anatomical differences between pygmy and common chimps mask considerable differences in reproductive biology. Unlike common chimps but like us, pygmy chimps assume a wide variety of positions for copulation, including face to face; copulation can be initiated by either sex, not just by the male; females are sexually receptive for much of the month, not just for a briefer period in midmonth; and there are strong bonds among females or between males and females, not just among males. Evidently, those few genes (0.7 percent) differing between pygmy and common chimps have big consequences for sexual physiology and roles. That same theme—a small percentage of gene differences having big consequences—will recur later in this and the next chapter in regard to the gene differences between humans and chimps.

In all these cases that I've discussed so far, anatomical evidence of

relationships was already convincing, and the DNA-based conclusions confirmed what the anatomists had already concluded. But DNA was also able to resolve the problem at which anatomy had failed—the relationships between humans, gorillas, and chimpanzees. As Figure 1 shows, humans differ from either common chimps or pygmy chimps in about 1.6 percent of their (our) DNA, and share 98.4 percent. Gorillas differ somewhat more, by about 2.3 percent, from us or from either of the chimps.

Let's pause to let some of the implications of these momentous numbers sink in:

The gorilla must have branched off from our family tree slightly before we separated from the common and pygmy chimpanzees. The chimpanzees, not the gorilla, are our closest relatives. Put another way, the chimpanzees' closest relative is not the gorilla but humans. Traditional taxonomy has reinforced our anthropocentric tendencies by claiming to see a fundamental dichotomy between mighty man, standing alone on high, and the lowly apes all together in the abyss of bestiality. Now, future taxonomists may see things from the chimpanzees' perspective: a weak dichotomy between slightly higher apes (the *three* chimpanzees, including the "human chimpanzee") and slightly lower apes (gorillas, orangutans, gibbons). The traditional distinction between "apes" (defined as chimps, gorillas, etc.) and humans misrepresents the facts.

The genetic distance (1.6 percent) separating us from pygmy or common chimps is barely double that separating pygmy from common chimps (0.7 percent). It's less than that between two species of gibbons (2.2 percent), or between such closely related North American bird species as red-eyed vireos and white-eyed vireos (2.9 percent). The remaining 98.4 percent of our DNA is just normal chimp DNA. For example, our principal hemoglobin, the oxygen-carrying protein that gives blood its red color, is identical in all of its 287 units with chimp hemoglobin. In this respect as in most others, we are just a third species of chimpanzee, and what's good enough for common and pygmy chimps is good enough for us. Our important visible distinctions from the other chimps—our upright posture, large brains, ability to speak, sparse body hair, and peculiar sexual lives—must be concentrated in a mere 1.6 percent of our genetic program.

If genetic distances between species accumulated at a uniform rate with time, they would function as a smoothly ticking clock. All that

would be required to convert genetic distance into absolute time since the last common ancestor would be a calibration, furnished by a pair of species for which we know *both* the genetic distance *and* the time of divergence as dated independently by fossils. In fact, two independent calibrations are available for higher primates. On the one hand, monkeys diverged from apes between twenty-five and thirty million years ago according to fossil evidence, and now differ in about 7.3 percent of their DNA. On the other hand, orangutans diverged from chimps and gorillas between twelve and sixteen million years ago and now differ in about 3.6 percent of their DNA. Comparing these two examples, a doubling of evolutionary time, as one goes from twelve-to-sixteen to twenty-five-to-thirty million years, leads to a doubling of genetic distance (3.6 to 7.3 percent of DNA). Thus, the DNA clock has ticked relatively steadily among higher primates.

With those calibrations, Sibley and Ahlquist estimated the following time scale for our evolution. Since our own genetic distance from chimps (1.6 percent) is about half the distance of orangutans from chimps (3.6 percent), we must have been going our separate way for about half of the twelve to sixteen million years that orangutans had to accumulate their genetic distinction from chimps. That is, the human and "other chimp" evolutionary lines diverged around six to eight million years ago. By the same reasoning, gorillas parted from the common ancestor of us three chimpanzees around nine million years ago, and the pygmy and common chimps diverged around three million years ago. In contrast, when I took physical anthropology as a college freshman in 1954, the assigned textbooks said that humans diverged from apes fifteen to thirty million years ago. Thus, the DNA clock strongly supports a controversial conclusion also drawn from several other molecular clocks based on amino-acid sequences of proteins, mitochondrial DNA, and globin pseudogene DNA. Each clock indicates that humans have had only a short history as a species distinct from other apes, much shorter than paleontologists used to assume.

WHAT DO THESE RESULTS imply about our position in the animal kingdom? Biologists classify living things in hierarchical categories, each less distinct than the next: subspecies, species, genus, family, superfamily, order, class, and phylum. The *Encyclopedia Britannica*

and all the biology texts on my shelf say that humans and apes belong to the same order, called Primates, and the same superfamily, called Hominoidea, but to separate families, called Hominidae and Pongidae. Whether Sibley's and Ahlquist's work changes this classification depends on one's philosophy of taxonomy. Traditional taxonomists group species into higher categories by making somewhat subjective evaluations of how important the differences between species are. Such taxonomists place humans in a separate family because of distinctive functional traits like large brain and bipedal posture, and this classification would remain unaffected by measures of genetic distance.

However, another school of taxonomy, called cladistics, argues that classification should be objective and uniform, based on genetic distance or times of divergence. All taxonomists agree now that red-eyed and white-eyed vireos belong together in the genus *Vireo,* the various species of gibbons in the genus *Hylobates.* Yet the members of these pairs of species are genetically more distant from each other than are humans from the other two chimpanzees, and diverged longer ago. On this basis, then, humans don't constitute a distinct family, or even a distinct genus, but belong in the same genus as common and pygmy chimps. Since our genus name *Homo* was proposed first, it takes priority, by the rules of zoological nomenclature, over the genus name *Pan* coined for the "other" chimps. So there are not one but three species of genus *Homo* on earth today: the common chimpanzee, *Homo troglodytes;* the pygmy chimpanzee, *Homo paniscus;* and the third chimpanzee or human chimpanzee, *Homo sapiens.* Since the gorilla is only slightly more distinct, it has almost equal right to be considered a fourth species of *Homo.*

Even taxonomists espousing cladistics are anthropocentric, and the lumping of humans and chimps into the same genus will undoubtedly be a bitter pill for them to swallow. There is no doubt, however, that whenever chimpanzees learn cladistics, or whenever taxonomists from Outer Space visit Earth to inventory its inhabitants, they will unhesitatingly adopt the new classification.

WHICH PARTICULAR GENES are the ones that differ between humans and chimps? Before we can consider this question, we need first to understand what it is that DNA, our genetic material, does.

Much or most of our DNA has no known function and may just constitute "molecular junk": i.e., DNA molecules that have become duplicated or have lost former functions, and that natural selection hasn't eliminated from us because they do us no harm. Of our DNA that does have known functions, the main functions have to do with the long chains of amino acids called proteins. Certain proteins make up much of our body's structure (such as the proteins keratin of hair or collagen of connective tissue), while other proteins termed enzymes synthesize and break down most of our body's remaining molecules. The sequences of the component small molecules (nucleotide bases) in DNA specify the sequence of amino acids in our proteins. Other parts of our functional DNA regulate protein synthesis.

Those of our observable features that are easiest to understand genetically are ones arising from single proteins and single genes. For instance, our blood's oxygen-carrying protein, which I have already mentioned, hemoglobin, consists of two amino-acid chains, each specified by a single chunk of DNA (a single "gene"). Those two genes have no observable effects except through specifying the structure of hemoglobin, which is confined to our red blood cells. Conversely, hemoglobin's structure is totally specified by those genes. What you eat or how much you exercise may affect how much hemoglobin you make, but not the details of its structure.

That's the simplest situation, but there are also genes influencing many observable traits. For example, the fatal genetic disorder known as Tay-Sachs disease involves many behavioral as well as anatomical anomalies: excessive drooling, rigid posture, yellowish skin, abnormal head growth, and other changes. We know in this case that all these observable effects result somehow from changes in a single enzyme specified by the Tay-Sachs gene, but we don't know exactly how. Since that enzyme occurs in many tissues of our bodies and breaks down a widespread cellular constituent, changes in that one enzyme have wide-ranging and ultimately fatal consequences. Conversely, some traits, such as your height as an adult, are influenced simultaneously by many genes and also by environmental factors (e.g., your nutrition as a child).

While scientists understand well the function of numerous genes that specify known individual proteins, we know much less about the function of genes involved in complexly determined traits, like most

behaviors. It would be absurd to think that a human hallmark such as art, language, or aggression depends on a single gene. Behavioral differences among individual humans are obviously subject to enormous environmental influences, and it's very controversial what role genes play in such individual differences. However, for those behaviors that differ consistently between chimps and humans, genetic differences are likely to be involved, even though we can't yet specify the genes responsible. For instance, the ability of humans but not chimps to speak surely depends on differences in genes specifying the anatomy of the voice box and the wiring of the brain. A young chimpanzee brought up in a psychologist's home along with the psychologist's human baby of the same age still continued to look like a chimp and didn't learn to talk or walk erect. But whether an individual human grows up to be fluent in English or Korean is independent of genes and dependent solely on childhood linguistic environment, as proved by the linguistic attainments of Korean infants adopted by English-speaking parents.

With this as background, what can we say about the 1.6 percent of our DNA that differs from chimp DNA? We know that the genes for our principal hemoglobin don't differ, and that certain other genes do exhibit minor differences. In the nine protein chains studied to date in both humans and common chimps, only five out of a total of 1,271 amino acids differ: one amino acid in a muscle protein called myoglobin, one in a minor hemoglobin chain called the delta chain, and three in an enzyme called carbonic anhydrase. But we don't yet know which chunks of our DNA are responsible for the functionally significant differences between humans and chimps to be discussed in Chapters 2 to 7: the differences in brain size, anatomy of the pelvis and voice box and genitalia, amount of body hair, female menstrual cycle, menopause, and other traits. Those important differences certainly don't arise from the five amino-acid differences detected to date. At present, all we can say with confidence is this: much of our DNA is junk; at least some of the 1.6 percent that differs between us and chimps is already known to be junk; and the functionally significant differences must be confined to some as-yet-unidentified small fraction of 1.6 percent.

Within that small differing fraction of our DNA, some differences have bigger consequences for our bodies than do others. To begin with, most amino acids of proteins can be specified by at least two

alternative sequences of nucleotide bases in DNA. Changes in nucleotide bases from one such sequence to an alternative one are "silent" mutations: they produce no change in the amino-acid sequences of proteins. Even when a change in one base does cause one amino acid to be replaced by another, some amino acids are very similar to certain others in their chemical properties, or are located in relatively insensitive parts of a protein.

But other parts of a protein are crucial to the protein's function. Replacing an amino acid in such a part with a chemically dissimilar amino acid is likely to produce some detectable effect. For instance, the disease sickle-cell anemia is an often-fatal condition, resulting from a change in our hemoglobin's solubility, resulting in turn from a change in just one of hemoglobin's 287 amino acids, resulting in turn from a change in just one of the three nucleotides specifying that amino acid. That change, however, replaces a negatively charged amino acid with one lacking net charge, thereby changing the electrical charge on the whole hemoglobin molecule.

While we don't know which particular genes or nucleotide bases are the crucial ones accounting for our observed differences from chimps, there are numerous precedents for one or a few genes having big impacts. I just mentioned the many big and visible differences between Tay-Sachs patients and normal people, all somehow arising from a single change in one enzyme. That's an example of differences among individuals of the same species. As for differences between related species, a good example is provided by the cichlid fishes of Africa's Lake Victoria. Cichlids are popular aquarium species, of which about two hundred are confined to that one lake, where they evolved from a single ancestor within perhaps the last 200,000 years. Those two hundred species differ among themselves in their food habits as much as do tigers and cows. Some graze on algae, others catch other fish, and still others variously crush snails, feed on plankton, catch insects, nibble the scales off other fish, or specialize in grabbing fish embryos from brooding mother fish. Yet all those Lake Victoria cichlids differ from each other on the average by only about 0.4 percent of their DNA studied. Thus, it took even fewer genetic mutations to change a snail crusher into a specialized baby killer than it took to produce us from an ape.

* * *

DO THE NEW FINDINGS about our genetic distance from chimps have any broader implications, besides technical questions of taxonomic names? Probably the most important implications concern how we think about the place of humans and apes in the universe. Names are not just technical details but express and create attitudes. (To convince yourself, try greeting your spouse this evening either as "my darling" or as "you swine," using the same expression and tone of voice). The new findings do not specify how we *should* think about humans and apes. But, just as did Darwin's *Origin of Species,* they will probably influence how we *do* think, and it will probably take us many years to readjust our attitudes. I'll mention just one example of a controversial area that might be affected: our use of apes.

At present we make a fundamental distinction between animals (including apes) and humans, and this distinction guides our ethical code and actions. For instance, as I noted at the start of this chapter, it's considered acceptable to exhibit caged apes in zoos, but it's not acceptable to do the same with humans. I wonder how the public will feel when the identifying label on the chimp cage in the zoo reads "*Homo troglodytes.*" Yet, if it were not for the sympathetic interest in apes that many people gain at zoos, there might be much less public financial support for conservationists' efforts to protect apes in the wild.

I also noted earlier that it's considered acceptable to subject apes, but not humans, without their consent to lethal experiments for purposes of medical research. The motive for doing so is precisely that apes are so similar to us genetically. They can be infected with many of the same diseases as we can, and their bodies respond similarly to the disease organisms. Thus, experiments on apes offer a far better way to devise improved medical treatments for humans than would experiments on any other animals.

This ethical choice poses an even more difficult problem than does caging apes in zoos. After all, we regularly cage millions of human criminals under worse conditions than zoo apes, but there is no socially accepted human analogue of medical research on animals, even though lethal experiments on humans would provide medical scientists with far more valuable information than do lethal experiments on chimps. Yet the human experiments performed by Nazi concentration-camp physicians are widely viewed as one of the most

abominable of all the Nazis' abominations. Why is it okay to perform such experimentation on chimps?

Somewhere along the scale from bacteria to humans, we have to decide where killing becomes murder, and where eating becomes cannibalism. Most people draw those lines between humans and all other species. However, quite a few people are vegetarians, unwilling to eat any animal (yet willing to eat plants). And an increasingly vocal minority, belonging to the animal-rights movement, object to medical experiments on animals—or at least on certain animals. That movement is especially exercised about research on cats and dogs and primates, less concerned about mice, and generally silent about insects and bacteria.

If our ethical code makes a purely arbitrary distinction between humans and all other species, then we have a code based on naked selfishness devoid of any higher principle. If our code instead makes distinctions based on our superior intelligence, social relationships, and capacity for feeling pain, then it becomes difficult to defend an all-or-nothing code that draws a line between all humans and all animals. Instead, different ethical constraints should apply to research on different species. Perhaps it's just our naked selfishness, reemerging in a new disguise, that would advocate granting special rights to those animal species genetically closest to us. But an objective case, based on the considerations I just mentioned (intelligence, social relationships, etc.), can be made that chimps and gorillas qualify for preferred ethical consideration over insects and bacteria. If there's any animal species currently used in medical research for which a total ban on medical experimentation can be justified, that species is surely the chimpanzee.

The ethical dilemma posed by animal experiments is compounded for chimps by the fact that they are endangered as a species. In this case, medical research not only kills individuals but threatens to kill the species itself. That's not to say that demands for research have been the sole threat to wild chimp populations; habitat destruction and capture for zoos have also been major threats. But it's enough that research demands have been a significant threat. The ethical dilemma is further compounded by other considerations: that on the average several wild chimps are killed in the process of capturing one alive (often a young animal that was being carried by its mother) and delivering it to a medical research lab; that medical scientists have

played little role in the struggle to protect wild chimp populations, despite their obvious self-interest in doing so; and that chimps used for research are often caged under cruel conditions. The first chimp that I saw being used for medical research had been injected with a slow-acting lethal virus and was being kept alone for the several years until it died, in a small indoor cage devoid of play objects, at the U.S. National Institutes of Health.

Breeding chimps in captivity for research use avoids objections based on depleting wild chimp populations. But that still doesn't get around the basic dilemma, any more than enslaving children of U.S.-born blacks after abolition of the African slave trade made black slavery in the nineteenth-century U.S. acceptable. Why is it okay to experiment on *Homo troglodytes,* but not on *Homo sapiens?* Conversely, how should we explain to parents whose children are at risk of dying from diseases now being studied in captive chimps that their children are less important than chimps? Ultimately, we the public, not just scientists, will have to make these terrible choices. All that is certain is that our view of man and apes will determine our decision.

Finally, changes in our attitudes about apes may be crucial in determining whether apes will survive at all in the wild. At present, their populations are threatened especially by destruction of their rainforest habitats in Africa and Asia, and by legal and illegal capture and killing. If present trends continue, the mountain gorilla, orangutan, pileated gibbon, Kloss's gibbon, and possibly some other apes as well will exist only in zoos by the time this year's crop of human babies enters college. It's not enough for us to preach to the governments of Uganda, Zaire, and Indonesia about their moral obligation to protect their wild apes. These are impoverished countries, and national parks are expensive to create and maintain. If we as the third chimpanzee decide that the other two chimpanzees are worth saving, those of us in the richer countries will have to bear most of the expense. From the point of view of the apes themselves, the most important effect of what we've recently learned about the tale of three chimpanzees will be on how we feel about footing that bill.