11

The Big Bang

The elephant's trunk is six feet long and one foot thick and contains sixty thousand muscles. Elephants can use their trunks to uproot trees, stack timber, or carefully place huge logs in position when recruited to build bridges. An elephant can curl its trunk around a pencil and draw characters on letter-size paper. With the two muscular extensions at the tip, it can remove a thorn, pick up a pin or a dime, uncork a bottle, slide the bolt off a cage door and hide it on a ledge, or grip a cup so firmly, without breaking it, that only another elephant can pull it away. The tip is sensitive enough for a blindfolded elephant to ascertain the shape and texture of objects. In the wild, elephants use their trunks to pull up clumps of grass and tap them against their knees to knock off the dirt, to shake coconuts out of palm trees, and to powder their bodies with dust. They use their trunks to probe the ground as they walk, avoiding pit traps, and to dig wells and siphon water from them. Elephants can walk underwater on the beds of deep rivers or swim like submarines for miles, using their trunks as snorkels. They communicate through their trunks by trumpeting, humming, roaring, piping, purring, rumbling, and making a crumpling-metal sound by rapping the trunk against the ground. The trunk is lined with chemoreceptors that allow the elephant to smell a python hidden in the grass or food a mile away.

Elephants are the only living animals that possess this extraordinary organ. Their closest living terrestrial relative is the hyrax, a mammal that you would probably not be able to tell from a large guinea pig. Until now you have probably not given the uniqueness of the ele-

phant's trunk a moment's thought. Certainly no biologist has made a fuss about it. But now imagine what might happen if some biologists were elephants. Obsessed with the unique place of the trunk in nature, they might ask how it could have evolved, given that no other organism has a trunk or anything like it. One school might try to think up ways to narrow the gap. They would first point out that the elephant and the hyrax share about 90% of their DNA and thus could not be all that different. They might say that the trunk must not be as complex as everyone thought; perhaps the number of muscles had been miscounted. They might further note that the hyrax really does have a trunk, but somehow it has been overlooked; after all, the hyrax does have nostrils. Though their attempts to train hyraxes to pick up objects with their nostrils have failed, some might trumpet their success at training the hyraxes to push toothpicks around with their tongues, noting that stacking tree trunks or drawing on blackboards differ from it only in degree. The opposite school, maintaining the uniqueness of the trunk, might insist that it appeared all at once in the offspring of a particular trunkless elephant ancestor, the product of a single dramatic mutation. Or they might say that the trunk somehow arose as an automatic by-product of the elephant's having evolved a large head. They might add another paradox for trunk evolution: the trunk is absurdly more intricate and well coordinated than any ancestral elephant would have needed.

These arguments might strike us as peculiar, but every one of them has been made by scientists of a different species about a complex organ that that species alone possesses, language. As we shall see in this chapter, Chomsky and some of his fiercest opponents agree on one thing: that a uniquely human language instinct seems to be incompatible with the modern Darwinian theory of evolution, in which complex biological systems arise by the gradual accumulation over generations of random genetic mutations that enhance reproductive success. Either there is no language instinct, or it must have evolved by other means. Since I have been trying to convince you that there is a language instinct but would certainly forgive you if you would rather believe Darwin than believe me, I would also like to convince you that you need not make that choice. Though we know few details about how the language instinct evolved, there is no reason to doubt that the principal explanation is the same as for any other complex instinct or organ, Darwin's theory of natural selection.

Language is obviously as different from other animals' communication systems as the elephant's trunk is different from other animals' nostrils. Nonhuman communication systems are based on one of three designs: a finite repertory of calls (one for warnings of predators, one for claims to territory, and so on), a continuous analog signal that registers the magnitude of some state (the livelier the dance of the bee, the richer the food source that it is telling its hivemates about), or a series of random variations on a theme (a birdsong repeated with a new twist each time: Charlie Parker with feathers). As we have seen, human language has a very different design. The discrete combinatorial system called "grammar" makes human language infinite (there is no limit to the number of complex words or sentences in a language), digital (this infinity is achieved by rearranging discrete elements in particular orders and combinations, not by varying some signal along a continuum like the mercury in a thermometer), and compositional (each of the infinite combinations has a different meaning predictable from the meanings of its parts and the rules and principles arranging them).

Even the seat of human language in the brain is special. The vocal calls of primates are controlled not by their cerebral cortex but by phylogenetically older neural structures in the brain stem and limbic system, structures that are heavily involved in emotion. Human vocalizations other than language, like sobbing, laughing, moaning, and shouting in pain, are also controlled subcortically. Subcortical structures even control the swearing that follows the arrival of a hammer on a thumb, that emerges as an involuntary tic in Tourette's syndrome, and that can survive as Broca's aphasics' only speech. Genuine language, as we saw in the preceding chapter, is seated in the cerebral cortex, primarily the left perisylvian region.

Some psychologists believe that changes in the vocal organs and in the neural circuitry that produces and perceives speech sounds are the *only* aspects of language that evolved in our species. On this view, there are a few general learning abilities found throughout the animal kingdom, and they work most efficiently in humans. At some point in history language was invented and refined, and we have been learning it ever since. The idea that species-specific behavior is caused by anatomy and general intelligence is captured in the Gary Larson *Far Side* cartoon in which two bears hide behind a tree near a human couple relaxing on a blanket. One says: "C'mon! Look at these fangs! . . . Look at these claws! . . . You think we're supposed to eat just honey and berries?"

According to this view, chimpanzees are the second-best learners in the animal kingdom, so they should be able to acquire a language too, albeit a simpler one. All it takes is a teacher. In the 1930s and 1940s two psychologist couples adopted baby chimpanzees. The chimps became part of the family and learned to dress, use the toilet, brush their teeth, and wash the dishes. One of them, Gua, was raised alongside a boy of the same age but never spoke a word. The other, Viki, was given arduous training in speech, mainly by the foster parents' molding the puzzled chimp's lips and tongue into the right shapes. With a lot of practice, and often with the help of her own hands, Viki learned to make three utterances that charitable listeners could hear as *papa, mama*, and *cup*, though she often confused them when she got excited. She could respond to some stereotyped formulas, like *Kiss me* and *Bring me the dog*, but stared blankly when asked to act out a novel combination like *Kiss the dog*.

But Gua and Viki were at a disadvantage: they were forced to use their vocal apparatus, which was not designed for speech and which they could not voluntarily control. Beginning in the late 1960s, several famous projects claimed to have taught language to baby chimpanzees with the help of more user-friendly media. (Baby chimps are used because the adults are not the hairy clowns in overalls you see on television, but strong, vicious wild animals who have bitten fingers off several well-known psychologists.) Sarah learned to string magnetized plastic shapes on a board. Lana and Kanzi learned to press buttons with symbols on a large computer console or point to them on a portable tablet. Washoe and Koko (a gorilla) were said to have acquired American Sign Language. According to their trainers, these apes learned hundreds of words, strung them together in meaningful sentences, and coined new phrases, like *water bird* for a swan and *cookie rock* for a stale Danish. "Language is no longer the exclusive domain of man," said Koko's trainer, Francine (Penny) Patterson.

These claims quickly captured the public's imagination and were played up in popular science books and magazines and television programs like *National Geographic, Nova, Sixty Minutes*, and *20/20*. Not only did the projects seem to consummate our age-old yearning to talk to the animals, but the photo opportunities of attractive women communing with apes, evocative of the beauty-and-the-beast archetype, were not lost on the popular media. Some of the projects were covered by *People, Life*, and *Penthouse* magazines, and they were fictionalized in a bad movie starring Holly Hunter called *Animal Behavior* and in a famous Pepsi commercial.

Many scientists have also been captivated, seeing the projects as a healthy deflation of our species' arrogant chauvinism. I have seen popular-science columns that list the acquisition of language by chimpanzees as one of the major scientific discoveries of the century. In a recent, widely excerpted book, Carl Sagan and Ann Druyan have used the ape language experiments as part of a call for us to reassess our place in nature:

> A sharp distinction between human beings and "animals" is essential if we are to bend them to our will, make them work for us, wear them, eat them—without any disquieting tinges of guilt or regret. With untroubled consciences, we can render whole species extinct—as we do today to the tune of 100 species a day. Their loss is of little import: Those beings, we tell ourselves, are not like us. An unbridgeable gap has thus a practical role to play beyond the mere stroking of human egos. Isn't there much to be proud of in the lives of monkeys and apes? Shouldn't we be glad to acknowledge a connection with Leakey, Imo, or Kanzi? Remember those macaques who would rather go hungry than profit from harming their fellows; might we have a more optimistic view of the human future if we were sure our ethics were up to their standards? And, viewed from this perspective, how shall we judge our treatment of monkeys and apes?

This well-meaning but misguided reasoning could only have come from writers who are not biologists. Is it really "humility" for us to save species from extinction because we think they are like us? Or because they seem like a bunch of nice guys? What about all the creepy, nasty, selfish animals who do not remind us of ourselves, or our image of what we would like to be—can we go ahead and wipe them out? And Sagan and Druyan are no friends of the apes if they think the reason we should treat the apes fairly is that they can be taught human language. Like many other writers, Sagan and Druyan are far too credulous about the claims of the chimpanzee trainers.

People who spend a lot of time with animals are prone to developing indulgent attitudes about their powers of communication. My great-aunt Bella insisted in all sincerity that her Siamese cat Rusty understood English. Many of the claims of the ape trainers were not much more scientific. Most of the trainers were schooled in the behaviorist tradition of B. F. Skinner and are ignorant of the study of language; they latched on to the most tenuous resemblance between chimp and child and proclaimed that their abilities are fundamentally the same. The more enthusiastic trainers went over the heads of scientists and made their engaging case directly to the public on the *Tonight Show* and *National Geographic*. Patterson in particular has found ways to excuse Koko's performance on the grounds that the gorilla is fond of puns, jokes, metaphors, and mischievous lies. Generally the stronger the claims about the animal's abilities, the skimpier the data made available to the scientific community for evaluation. Most of the trainers have refused all requests to share their raw data, and Washoe's trainers, Beatrice and Alan Gardner, threatened to sue another researcher because he used frames of one of their films (the only raw data available to him) in a critical scientific article. That researcher, Herbert Terrace, together with the psychologists Laura Ann Petitto, Richard Sanders, and Tom Bever, had tried to teach ASL to one of Washoe's relatives, whom they named Nim Chimpsky. They carefully tabulated and analyzed his signs, and Petitto, with the psychologist Mark Seidenberg, also scrutinized the videotapes and what published data there were on the other signing apes, whose abilities were similar to Nim's. More recently, Joel Wallman has written a history of the topic called *Aping Language*. The moral of their investigations is: Don't believe everything you hear on the *Tonight Show*.

To begin with, the apes did *not* "learn American Sign Language." This preposterous claim is based on the myth that ASL is a crude system of pantomimes and gestures rather than a full language with complex phonology, morphology, and syntax. In fact the apes had not learned *any* true ASL signs. The one deaf native signer on the Washoe team later made these candid remarks:

> Every time the chimp made a sign, we were supposed to write it down in the log. . . . They were always complaining because my log didn't show enough signs. All the hearing people turned in logs

> with long lists of signs. They always saw more signs than I did. . . . I watched really carefully. The chimp's hands were moving constantly. Maybe I missed something, but I don't think so. I just wasn't seeing any signs. The hearing people were logging every movement the chimp made as a sign. Every time the chimp put his finger in his mouth, they'd say "Oh, he's making the sign for *drink*," and they'd give him some milk. . . . When the chimp scratched itself, they'd record it as the sign for *scratch*. . . . When [the chimps] want something, they reach. Sometimes [the trainers would] say, "Oh, amazing, look at that, it's exactly like the ASL sign for *give*!" It wasn't.

To arrive at their vocabulary counts in the hundreds, the investigators would also "translate" the chimps' pointing as a sign for *you*, their hugging as a sign for *hug*, their picking, tickling, and kissing as signs for *pick, tickle*, and *kiss*. Often the same movement would be credited to the chimps as different "words," depending on what the observers thought the appropriate word would be in the context. In the experiments in which the chimps interacted with a computer console, the key that the chimp had to be press to initialize the computer was translated as the word *please*. Petitto estimates that with more standard criteria the true vocabulary count would be closer to 25 than 125.

Actually, what the chimps were really doing was more interesting than what they were claimed to be doing. Jane Goodall, visiting the project, remarked to Terrace and Petitto that every one of Nim's so-called signs was familiar to her from her observations of chimps in the wild. The chimps were relying heavily on the gestures in their natural repertoire, rather than learning true arbitrary ASL signs with their combinatorial phonological structure of hand shapes, motions, locations, and orientations. Such backsliding is common when humans train animals. Two enterprising students of B. F. Skinner, Keller and Marian Breland, took his principles for shaping the behavior of rats and pigeons with schedules of reward and turned them into a lucrative career of training circus animals. They recounted their experiences in a famous article called "The Misbehavior of Organisms," a play on Skinner's book *The Behavior of Organisms*. In some of their acts the animals were trained to insert poker chips in little juke boxes and vending machines for a food reward. Though the training schedules were the same for the various animals, their species-specific instincts bled through. The chickens spontaneously pecked at the chips, the pigs tossed and rooted them with their snouts, and the raccoons rubbed and washed them.

The chimp's abilities at anything one would want to call grammar were next to nil. Signs were not coordinated into the well-defined motion contours of ASL and were not inflected for aspect, agreement, and so on—a striking omission, since inflection is the primary means in ASL of conveying who did what to whom and many other kinds of information. The trainers frequently claim that the chimps have syntax, because pairs of signs are sometimes placed in one order more often than chance would predict, and because the brighter chimps can act out sequences like *Would you please carry the cooler to Penny*. But remember from the Loebner Prize competition (for the most convincing computer simulation of a conversational partner) how easy it is to fool people into thinking that their interlocutors have humanlike talents. To understand the request, the chimp could ignore the symbols *would, you, please, carry, the*, and *to*; all the chimp had to notice was the order of the two nouns (and in most of the tests, not even that, because it is more natural to carry a cooler to a person than a person to a cooler). True, some of the chimps can carry out these commands more reliably than a two-year-old child, but this says more about temperament than about grammar: the chimps are highly trained animal acts, and a two-year-old is a two-year-old.

As far as spontaneous output is concerned, there is no comparison. Over several years of intensive training, the average length of the chimps' "sentences" remains constant. With nothing more than exposure to speakers, the average length of a child's sentences shoots off like a rocket. Recall that typical sentences from a two-year-old child are *Look at that train Ursula brought* and *We going turn light on so you can't see*. Typical sentences from a language-trained chimp are:

> Nim eat Nim eat.
> Drink eat me Nim.
> Me gum me gum.
> Tickle me Nim play.
> Me eat me eat.
> Me banana you banana me you give.
> You me banana me banana you.
> Banana me me me eat.

Give orange me give eat orange me eat orange give me eat orange give me you.

These jumbles bear scant resemblance to children's sentences. (By watching long enough, of course, one is bound to find random combinations in the chimps' gesturing that can be given sensible interpretations, like *water bird*). But the strings *do* resemble animal behavior in the wild. The zoologist E. O. Wilson, summing up a survey of animal communication, remarked on its most striking property: animals, he said, are "repetitious to the point of inanity."

Even putting aside vocabulary, phonology, morphology, and syntax, what impresses one the most about chimpanzee signing is that fundamentally, deep down, chimps just don't "get it." They know that the trainers like them to sign and that signing often gets them what they want, but they never seem to feel in their bones what language is and how to use it. They do not take turns in conversation but instead blithely sign simultaneously with their partner, frequently off to the side or under a table rather than in the standardized signing space in front of the body. (Chimps also like to sign with their feet, but no one blames them for taking advantage of this anatomical gift.) The chimps seldom sign spontaneously; they have to be molded, drilled, and coerced. Many of their "sentences," especially the ones showing systematic ordering, are direct imitations of what the trainer has just signed, or minor variants of a small number of formulas that they have been trained on thousands of times. They do not even clearly get the idea that a particular sign might refer to a kind of object. Most of the chimps' object signs can refer to any aspect of the situation with which an object is typically associated. *Toothbrush* can mean "toothbrush," "toothpaste," "brushing teeth," "I want my toothbrush," or "It's time for bed." *Juice* can mean "juice," "where juice is usually kept," or "Take me to where the juice is kept." Recall from Ellen Markman's experiments in Chapter 5 that children use these "thematic" associations when sorting pictures into groups, but they ignore them when learning word meanings: to them, a *dax* is a dog or another dog, not a dog or its bone. Also, the chimps rarely make statements that comment on interesting objects or actions; virtually all their signs are demands for something they want, usually food or tickling. I cannot help but think of a moment with my two-year-old niece Eva that captures how different are the minds of child and chimp. One night the family was driving on an expressway, and when the adult conversation died down, a tiny voice from the back seat said, "Pink." I followed her gaze, and on the horizon several miles away I could make out a pink neon sign. She was commenting on its color, just for the sake of commenting on its color.

Within the field of psychology, most of the ambitious claims about chimpanzee language are a thing of the past. Nim's trainer Herbert Terrace, as mentioned, turned from enthusiast to whistle-blower. David Premack, Sarah's trainer, does not claim that what she acquired is comparable to human language; he uses the symbol system as a tool to do chimpanzee cognitive psychology. The Gardners and Patterson have distanced themselves from the community of scientific discourse for over a decade. Only one team is currently making claims about language. Sue Savage-Rumbaugh and Duane Rumbaugh concede that the chimps they trained at the computer console did not learn much. But they are now claiming that a different variety of chimpanzee does much better. Chimpanzees come from some half a dozen mutually isolated "islands" of forest in the west African continent, and the groups have diverged over the past million years to the point where some of the groups are sometimes classified as belonging to different species. Most of the trained chimps were "common chimps"; Kanzi is a "pygmy chimp" or "bonobo," and he learned to bang on visual symbols on a portable tablet. Kanzi, says Savage-Rumbaugh, does substantially better at learning symbols (and at understanding spoken language) than common chimps. Why he would be expected to do so much better than members of his sibling species is not clear; contrary to some reports in the press, pygmy chimps are no more closely related to humans than common chimps are. Kanzi is said to have learned his graphic symbols without having been laboriously trained on them—but he was at his mother's side watching while *she* was laboriously trained on them (unsuccessfully). He is said to use the symbols for purposes other than requesting—but at best only four percent of the time. He is said to use three-symbol "sentences"—but they are really fixed formulas with no internal structure and are not even three symbols long. The so-called sentences are all chains like the symbol for chase followed by the symbol for hide followed by a point to the person Kanzi wants to do the chasing and hiding. Kanzi's language abilities, if one is being charitable, are above those of his common cousins by a just-noticeable difference, but no more.

What an irony it is that the supposed attempt to bring *Homo sapiens* down a few notches in the natural order has taken the form of us humans hectoring another species into emulating our instinctive form of communication, or some artificial form we have invented, as if that were the measure of biological worth. The chimpanzees' resistance is no shame on them; a human would surely do no better if trained to hoot and shriek like a chimp, a symmetrical project that makes about as much scientific sense. In fact, the idea that some species needs our intervention before its members can display a useful skill, like some bird that could not fly until given a human education, is far from humble!

So human language differs dramatically from natural and artificial animal communication. What of it? Some people, recalling Darwin's insistence on the gradualness of evolutionary change, seem to believe that a detailed examination of chimps' behavior is unnecessary: they must have some form of language, as a matter of principle. Elizabeth Bates, a vociferous critic of Chomskyan approaches to language, writes:

> If the basic structural principles of language cannot be learned (bottom up) or derived (top down), there are only two possible explanations for their existence: either Universal Grammar was endowed to us directly by the Creator, or else our species has undergone a mutation of unprecedented magnitude, a cognitive equivalent of the Big Bang. . . . We have to abandon any strong version of the discontinuity claim that has characterized generative grammar for thirty years. We have to find some way to ground symbols and syntax in the mental material that we share with other species.

But, in fact, if human language is unique in the modern animal kingdom, as it appears to be, the implications for a Darwinian account of its evolution would be as follows: none. A language instinct unique to modern humans poses no more of a paradox than a trunk unique to modern elephants. No contradiction, no Creator, no big bang.

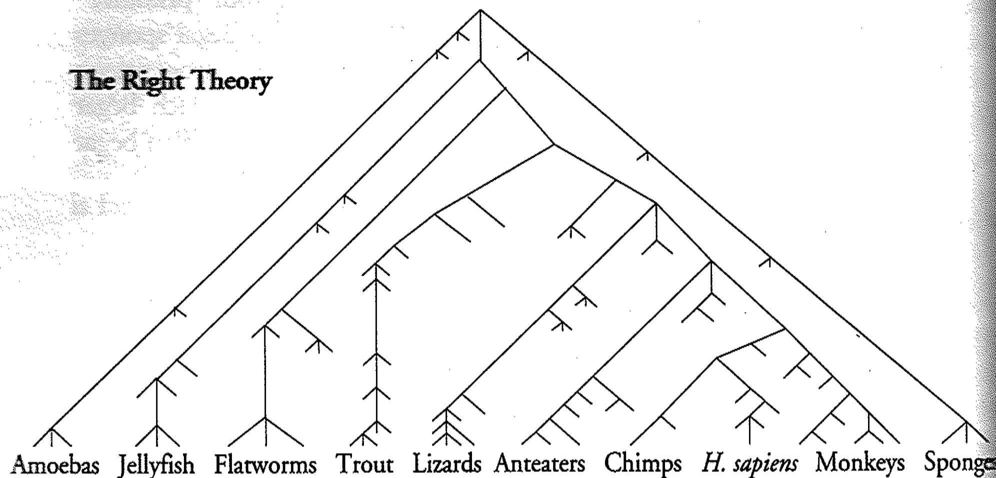
Modern evolutionary biologists are alternately amused and annoyed by a curious fact. Though most educated people profess to believe in Darwin's theory, what they really believe in is a modified version of the ancient theological notion of the Great Chain of Being: that all species are arrayed in a linear hierarchy with humans at the top. Darwin's contribution, according to this belief, was showing that each species on the ladder evolved from the species one rung down, instead of being allotted its rung by God. Dimly remembering their high school biology classes that took them on a tour of the phyla from "primitive" to "modern," people think roughly as follows: amoebas begat sponges which begat jellyfish which begat flatworms which begat trout which begat frogs which begat lizards which begat dinosaurs which begat anteaters which begat monkeys which begat chimpanzees which begat us. (I have skipped a few steps for the sake of brevity.)

The Wrong Theory

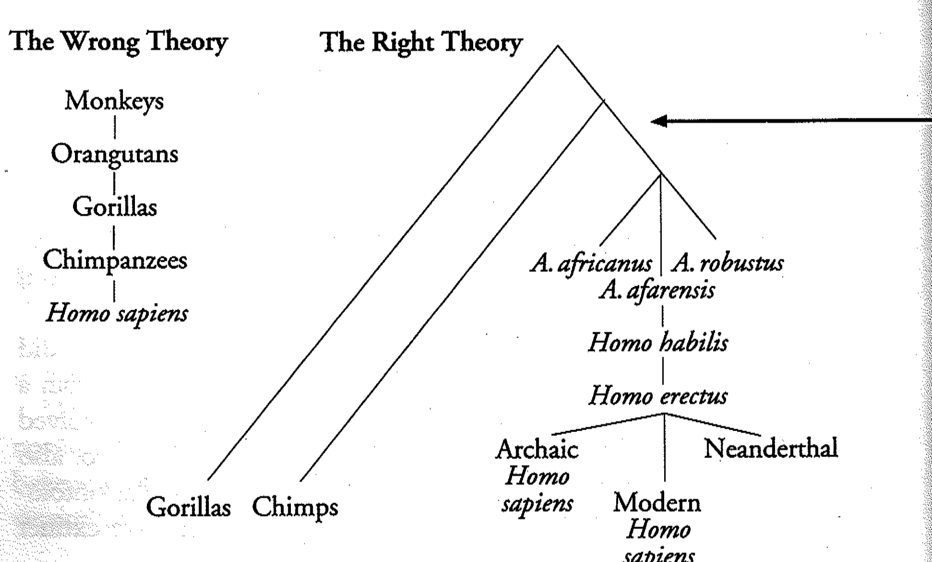
Amoebas
|
Sponges
|
Jellyfish
|
Flatworms
|
Trout
|
Frogs
|
Lizards
|
Dinosaurs
|
Anteaters
|
Monkeys
|
Chimpanzees
|
Homo sapiens

Hence the paradox: humans enjoy language while their neighbors on the adjacent rung have nothing of the kind. We expect a fade-in, but we see a big bang.

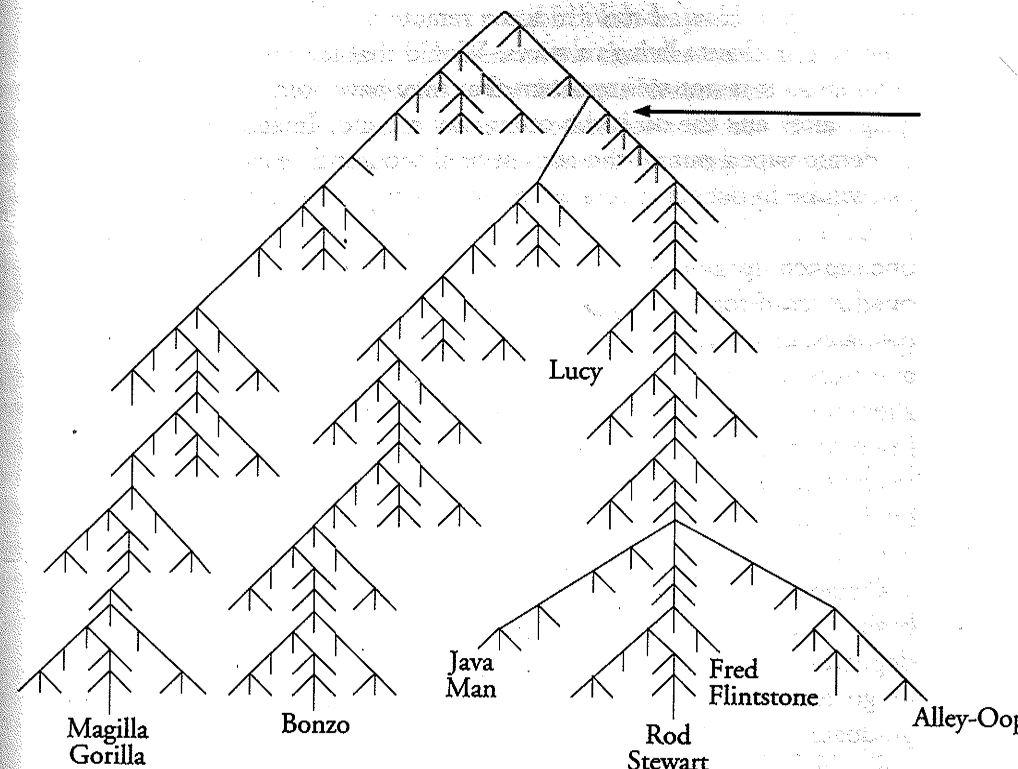
But evolution did not make a ladder; it made a bush. We did not evolve from chimpanzees. We and chimpanzees evolved from a common ancestor, now extinct. The human-chimp ancestor evolved not from monkeys but from an even older ancestor of the two, also extinct. And so on, back to our single-celled forebears. Paleontologists like to say that to a first approximation, all species are extinct (ninety-nine percent is the usual estimate). The organisms we see around us are distant cousins, not great-grandparents; they are a few scattered twig-tips of an enormous tree whose branches and trunk are no longer with us. Simplifying a lot:



Zooming in on our branch, we see chimpanzees off on a separate sub-branch, not sitting on top of us.



We also see that a form of language could first have emerged at the position of the arrow, after the branch leading to humans split off from the one leading to chimpanzees. The result would be languageless chimps and approximately five to seven million years in which language could have gradually evolved. Indeed, we should zoom in even closer, because species do not mate and produce baby species; organisms mate and produce baby organisms. Species are an abbreviation for chunks of a vast family tree composed of individuals, such as the *particular* gorilla, chimp, australopithecine, *erectus*, archaic *sapiens*, Neanderthal, and modern *sapiens* I have named in this family tree:



So if the first trace of a proto-language ability appeared in the ancestor at the arrow, there could have been on the order of 350,000 generations between then and now for the ability to have been elaborated and fine-tuned to the Universal Grammar we see today. For all we know, language could have had a gradual fade-in, even if no extant species, not even our closest living relatives the chimpanzees, have it. There were plenty of organisms with intermediate language abilities, but they are all dead.

Here is another way to think about it. People see chimpanzees, the living species closest to us, and are tempted to conclude that they, at the very least, must have some ability that is ancestral to language. But because the evolutionary tree is a tree of individuals, not species, "the living species closest to us" has no special status; what that species is depends on the accidents of extinction. Try the following thought experiment. Imagine that anthropologists discover a relict population of *Homo habilis* in some remote highland. *Habilis* would now be our closest living relatives. Would that take the pressure off chimps, so it is not so important that they have something like language after all? Or do it the other way around. Imagine that some epidemic wiped out all the apes several thousand years ago. Would Darwin be in danger unless we showed that monkeys had language? If you are inclined to answer yes, just push the thought experiment one branch up: imagine that in the past some extraterrestrials developed a craze for primate fur coats, and hunted and trapped all the primates to extinction except hairless us. Would insectivores like anteaters have to shoulder the proto-language burden? What if the aliens went for mammals in general? Or developed a taste for vertebrate flesh, sparing us because they like the sitcom reruns that we inadvertently broadcast into space? Would we then have to look for talking starfish? Or ground syntax in the mental material we share with sea cucumbers?

Obviously not. Our brains, and chimpanzee brains, and anteater brains, have whatever wiring they have; the wiring cannot change depending on which other species a continent away happen to survive or go extinct. The point of these thought experiments is that the gradualness that Darwin made so much about applies to lineages of individual organisms in a bushy family tree, not to entire living species in a great chain. For reasons that we will cover soon, an ancestral ape with nothing but hoots and grunts is unlikely to have given birth to a baby who could learn English or Kivunjo. But it did not have to; there was a chain of several hundred thousand generations of grandchildren in which such abilities could gradually blossom. To

determine when in fact language began, we have to look at people, and look at animals, and note what we see; we cannot use the idea of phyletic continuity to legislate the answer from the armchair.

The difference between bush and ladder also allows us to put a lid on a fruitless and boring debate. That debate is over what qualifies as True Language. One side lists some qualities that human language has but that no animal has yet demonstrated: reference, use of symbols displaced in time and space from their referents, creativity, categorical speech perception, consistent ordering, hierarchical structure, infinity, recursion, and so on. The other side finds some counterexample in the animal kingdom (perhaps budgies can discriminate speech sounds, or dolphins or parrots can attend to word order when carrying out commands, or some songbird can improvise indefinitely without repeating itself) and then gloats that the citadel of human uniqueness has been breached. The Human Uniqueness team relinquishes that criterion but emphasizes others or adds new ones to the list, provoking angry objections that they are moving the goalposts. To see how silly this all is, imagine a debate over whether flatworms have True Vision or houseflies have True Hands. Is an iris critical? Eyelashes? Fingernails? Who cares? This is a debate for dictionary-writers, not scientists. Plato and Diogenes were not doing biology when Plato defined man as a "featherless biped" and Diogenes refuted him with a plucked chicken.

The fallacy in all this is that there is some line to be drawn across the ladder, the species on the rungs above it being credited with some glorious trait, those below lacking it. In the tree of life, traits like eyes or hands or infinite vocalizations can arise on any branch, or several times on different branches, some leading to humans, some not. There is an important scientific issue at stake, but it is not whether some species possesses the true version of a trait as opposed to some pale imitation or vile imposter. The issue is which traits are *homologous* to which other ones.

Biologists distinguish two kinds of similarity. "Analogous" traits are ones that have a common function but arose on different branches of the evolutionary tree and are in an important sense not "the same" organ. The wings of birds and the wings of bees are a textbook example; they are both used for flight and are similar in some ways because anything used for flight has to be built in those ways, but they arose independently in evolution and have nothing in common beyond their use in flight. "Homologous" traits, in contrast, may or may not have a common function, but they descended from a common ancestor and hence have some common structure that bespeaks their being "the same" organ. The wing of a bat, the front leg of a horse, the flipper of a seal, the claw of a mole, and the hand of a human have very different functions, but they are all modifications of the forelimb of the ancestor of all mammals, and as a result they share nonfunctional traits like the number of bones and the ways they are connected. To distinguish analogy from homology, biologists usually look at the overall architecture of the organs and focus on their most useless properties—the useful ones could have arisen independently in two lineages *because* they are useful (a nuisance to taxonomists called convergent evolution). We deduce that bat wings are really hands because we can see the wrist and count the joints in the fingers, and because that is not the only way that nature could have built a wing.

The interesting question is whether human language is homologous to—biologically "the same thing" as—anything in the modern animal kingdom. Discovering a similarity like sequential ordering is pointless, especially when it is found on a remote branch that is surely not ancestral to humans (birds, for example). Here primates are relevant, but the ape-trainers and their fans are playing by the wrong rules. Imagine that their wildest dreams are realized and some chimpanzee can be taught to produce real signs, to group and order them consistently to convey meaning, to use them spontaneously to describe events, and so on. Does that show that the human ability to learn language evolved from the chimp ability to learn the artificial sign system? Of course not, any more than a seagull's wings show that it evolved from mosquitos. Any resemblance between the chimps' symbol system and human language would not be a legacy of their common ancestor; the features of the symbol system were deliberately designed by the scientists and acquired by the chimps because it was useful to them then and there. To check for homology, one would have to find some signature trait that reliably emerges both in ape symbol systems and in human language, and that is not so indispensable to communication that it was likely to have emerged twice, once in the course of human evolution and once in the lab meetings of the psychologists as they contrived the system to teach their apes. One could look for such signatures in development, checking the apes for some echo of the standard human sequence from syllable babbling to jargon babbling to first words to two-word sequences to a grammar explosion. One could look at the developed grammar, seeing if apes invent or favor some specimen of nouns and verbs, inflections, X-bar syntax, roots and stems, auxiliaries in second position inverting to form questions, or other distinctive aspects of universal human grammar. (These structures are not so abstract as to be undetectable; they leapt out of the data when linguists first looked at American Sign Language and creoles, for example.) And one could look at neuroanatomy, checking for control by the left perisylvian regions of the cortex, with grammar more anterior, dictionary more posterior. This line of questioning, routine in biology since the nineteenth century, has never been applied to chimp signing, though one can make a good prediction of what the answers would be.

How plausible is it that the ancestor to language first appeared after the branch leading to humans split off from the branch leading to chimps? Not very, says Philip Lieberman, one of the scientists who believe that vocal tract anatomy and speech control are the only things that were modified in evolution, not a grammar module: "Since Darwinian natural selection involves small incremental steps that enhance the present function of the specialized module, the evolution of a 'new' module is logically impossible." Now, something has gone seriously awry in this argument. Humans evolved from single-celled ancestors. Single-celled ancestors had no arms, legs, heart, eyes, liver, and so on. Therefore eyes and livers are logically impossible.

The point that the argument misses is that although natural selection involves incremental steps that enhance functioning, the enhancements do not have to be to an existing module. They can slowly build a module out of some previously nondescript stretch of anatomy, or out of the nooks and crannies between existing modules, which the biologists Stephen Jay Gould and Richard Lewontin call "spandrels," from the architectural term for the space between two arches. An example of a new module is the eye, which has arisen de novo some forty separate times in animal evolution. It can begin in an eyeless organism with a patch of skin whose cells are sensitive to light. The patch can deepen into a pit, cinch up into a sphere with a hole in front, grow a translucent cover over the hole, and so on, each step allowing the owner to detect events a bit better. An example of a module growing out of bits that were not originally a module is the elephant's trunk. It is a brand-new organ, but homologies suggest that it evolved from a fusion of the nostrils and some of the upper lip muscles of the extinct elephant-hyrax common ancestor, followed by radical complications and refinements.

Language could have arisen, and probably did arise, in a similar way: by a revamping of primate brain circuits that originally had no role in vocal communication, and by the addition of some new ones. The neuroanatomists Al Galaburda and Terrence Deacon have discovered areas in monkey brains that correspond in location, input-output cabling, and cellular composition to the human language areas. For example, there are homologues to Wernicke's and Broca's areas and a band of fibers connecting the two, just as in humans. The regions are not involved in producing the monkeys' calls, nor are they involved in producing their gestures. The monkey seems to use the regions corresponding to Wernicke's area and its neighbors to recognize sound sequences and to discriminate the calls of other monkeys from its own calls. The Broca's homologues are involved in control over the muscles of the face, mouth, tongue, and larynx, and various subregions of these homologues receive inputs from the parts of the brain dedicated to hearing, the sense of touch in the mouth, tongue, and larynx, and areas in which streams of information from all the senses converge. No one knows exactly why this arrangement is found in monkeys and, presumably, their common ancestor with humans, but the arrangement would have given evolution some parts it could tinker with to produce the human language circuitry, perhaps exploiting the confluence of vocal, auditory, and other signals there.

Brand-new circuits in this general territory could have arisen, too. Neuroscientists charting the cortex with electrodes have occasionally found mutant monkeys who have one extra visual map in their brains compared to standard monkeys (visual maps are the postage-stamp-sized brain areas that are a bit like internal graphics buffers, registering the contours and motions of the visible world in a distorted picture). A sequence of genetic changes that duplicate a brain map or circuit, reroute its inputs and outputs, and frob, twiddle, and tweak its internal connections could manufacture a genuinely new brain module.

Brains can be rewired only if the genes that control their wiring

have changed. This brings up another bad argument about why chimp signing must be like human language. The argument is based on the finding that chimpanzees and humans share 98% to 99% of their DNA, a factoid that has become as widely circulated as the supposed four hundred Eskimo words for snow (the comic strip *Zippy* recently quoted the figure as "99.9%"). The implication is that we must be 99% similar to chimpanzees.

But geneticists are appalled at such reasoning and take pains to stifle it in the same breath that they report their results. The recipe for the embryological soufflé is so baroque that small genetic changes can have enormous effects on the final product. And a 1% difference is not even so small. In terms of the information content in the DNA it is 10 megabytes, big enough for Universal Grammar with lots of room left over for the rest of the instructions on how to turn a chimp into a human. Indeed, a 1% difference in total DNA does not even mean that only 1% of human and chimpanzee genes are different. It could, in theory, mean that 100% of human and chimpanzee genes are different, each by 1%. DNA is a discrete combinatorial code, so a 1% difference in the DNA for a gene can be as significant as a 100% difference, just as changing one bit in every byte, or one letter in every word, can result in a new text that is 100% different, not 10% or 20% different. The reason, for DNA, is that even a single amino-acid substitution can change the shape of a protein enough to alter its function completely; this is what happens in many fatal genetic diseases. Data on genetic similarity are useful in figuring out how to connect up a family tree (for example, whether gorillas branched off from a common ancestor of humans and chimps or humans branched off from a common ancestor of chimps and gorillas) and perhaps even to date the divergences using a "molecular clock." But they say nothing about how similar the organisms' brains and bodies are.

The ancestral brain could have been rewired only if the new circuits had some effect on perception and behavior. The first steps toward human language are a mystery. This did not stop philosophers in the nineteenth century from offering fanciful speculations, such as that speech arose as imitations of animal sounds or as oral gestures that resembled the objects they represented, and linguists subsequently