Keynote Address

Stephen Jay Gould

This text is an edited transcript of a keynote address given at the conference "In the Company of Animals" in New York City on April 6, 1995. Written and spoken English are entirely different languages, and this address, prepared only to be spoken, must be fairly awkward in this printed version. In addition, the talk depended upon a large number of slides, which could not be included here. I either deleted the sections based entirely on pictures or kept the text when I felt that the points could be understood without the visual material.

We all know the conclusion to that most famous of all poems about invertebrates—namely, Robert Burns's "To A Louse." The louse speaks from its position in a hairpiece of an upper-class lady, if I remember correctly. "Oh, would some power the giftie gie us, to see ourselves as others see us. It would from many a blunder free us, and foolish notion." Very familiar lines that you all know. Apparently, unfortunately, no such power exists, and so everything we know about animals we see in our terms.

I want to illustrate the general theme of how we're always seeing not only animals, but everything else, in our terms, by giving you four quick examples of what, in a way, is the most egregious kind of misinterpretation we can make—namely, when we try to identify the attributes of animals as a result of nothing more than the arbitrary name that we happen to have given to them. It's bad enough that we backread our features into organisms, but when we backread an arbitrary name that we happen to give to an organism, and then assume that its characteristics flow from this arbitrary name, then that's the ultimate example of the backreading fallacy.

Steve Glickman this afternoon talked about T.H. White’s
bestiary translation. If you look at the attributes in medieval bestiaries, they always discuss where the names of animals come from—why is the goat Capra, for example. White's bestiary tells us that you only have to invert the syllables. It's aspera capeta: “he seeks the rough places.” And you reverse it, and then it's capra. Now let's go forward, to the age of Newton and Sir Thomas Browne, and we come to various myths, such as the famous myth of the beaver—that to elude the hunter, the beaver bites off his own testicles. It's a very old myth. And Sir Thomas Browne debunks it in his *Pseudodoxia Epidemica*—that is, his *Epidemic of Falsities*, the first of the great exposés of foolish wisdom, so to speak, written in the 1640s. He first goes through the various reasons why people ever would have believed such nonsense and points out (I am quoting): “Some have been so bad grammarians as to be deceived by the name.” The name for the beaver is Castor, and many people thought the name came from castrate.

Browne is marvelous—his use of language—so, if you don’t mind we'll go on just a little bit. He says—after pointing out that the name castor does not share the same root as “castration,” but ultimately derives from a Sanskrit word for musk; that comes later. He then cites the factual evidence of intact males, and the reasoned argument that a beaver couldn’t even reach his own testicles if he wanted to bite them off. Now quoting from Browne: “The testicles properly so called are of a lesser magnitude, and seated inwardly upon the loins. And, therefore, it were not only a fruitless attempt but impossible act to eunuchate, or castrate themselves, and might be a hazardous practice of art if at all attempted by others.”

And then we move forward another 100 years to Linnaeus. Linnaeus then used the name primate for monkeys and apes, and everybody thinks that is the original meaning. This example is just an excuse, because I wanted to read one of the most marvelous letters that I ever got. This is a letter from the Reverend Michael Ingham, who is the principal secretary to the Primate of the Anglican Church of Canada, and he wrote it to a John Hearn, the Director of the Wisconsin Regional Primate Research Center—who, clearly, thought that this guy represented the other kind of primate. In any event, it is a terrific letter. Ecclesiastics must live for this once-in-a-lifetime opportunity. “Dear Dr. Hearn: Thank you for your letter of December the fourth addressed to Dr. George Cran of the Primate’s World Relief and Development Fund, in which you seek information for your international directory of primatology. I should perhaps inform you that the term ‘primate’ in our context refers to the senior archbishop and chief pastor of the Anglican Church of Canada. The Relief and Development Fund over which he presides is an agency for the alleviation of global poverty and hunger on behalf of Anglican Christians. I think the primates in your study are perhaps of a different species. While it is true that our primate occasionally enjoys bananas, I have never seen him walk with his knuckles on the ground or scratch himself publicly under the armpits. He does have three children, but this is a far cry from ‘breeding colonies of primates,’ as your research project mentions. Like you, we do not import our primates from the wild, however. They are elected from among the bishops of our church. This is occasionally a cause of some comment. The subject of primate biology might be of great importance in your field, but, alas, not so in ours. There are a mere 28 Anglican primates in the whole world. They are
all males, of course, and so far we have had no problems of reproduction."

But lest you think this type of error has disappeared, I point out a scene from "Jurassic Park," right in the beginning, when the paleontologist, Mr. Grant is trying to persuade folks on his field trip out West that dinosaurs are related to birds. He gives a whole bunch of perfectly good arguments based on anatomy, which is how the argument should be made. Then he turns around—because the fossil he is talking about is *Velociraptor*—and says, "Even the word 'raptor' means bird of prey—and that is his closing argument. That is the crowning glory: Even the word "raptor" means bird of prey—so, of course, dinosaurs must be birds—because this dinosaur is named *Velociraptor*. It is a wonderful example, because "raptor," in English, was used for humans centuries before. I think it was Linnaeus, again, who first used it as a term for birds of prey. It comes from the Latin *rapere*, to seize by force. And I hope you recognize that "The Rape of Europa," the next time you see Titian's painting at the Gardner Museum in Boston, refers to the abduction of Europa—not to whatever happened afterwards. It is the seizure by force, or rape in the original sense. Easy to see how it acquired the other meaning, but it was a human word for centuries before it became a bird word.

Okay, that is the introduction to the theme of this talk, which now proceeds in two parts. First, that backreading—that is, the placement of human characteristics into animals—is really the only way that we have ever proceeded. There are a few exceptions among honorable scholars, I suppose, and others, and fishermen and hunters, I am sure—but let us just say by far the overwhelmingly predominant way of understanding animals is by backreading human characteristics into them. And then, of course, people also fall into the further funny fallacy responsible for so much biodeterminist nonsense. You then, having identified human phenomena in animals, and called them that—like cuckoldry, or adultery, or whatever—you then rederive them as natural for humans. Because if rape exists in mallard ducks, as has been claimed, then, clearly, it is a biologically conditioned feature in human beings—which is nonsense on many criteria.

So this will be part one of the talk, and there's really nothing particularly original here. Part two—not only do we backread characteristics of ourselves when we are talking about animals, but Protagoras was right when he said that man is the measure of all things—whether he meant just male human beings or was using the Greek term for all of us, I leave aside for now. And that, therefore, even the most abstract and universal issues of science and philosophy are often really, at root, inquiries about humans—particularly validations of human hegemony in the face of fear that we are not quite so powerful as we think we are.

And this leads me, at the very end, to a particular argument, which, in a way, is the key to this talk, and its only possible point of mild originality—that, since human beings are a contingent product of history, and not a predictable outcome of the laws of evolution or other natural laws, therefore, these abstract universals, which we have always seen as transcendentally general, are really tales from historical science after all—since they are, fundamentally, ways in which we justify our own status, and since our status is historically contingent, rather than conditioned by laws of nature, some of these very deepest and most abstract issues are really discussions about historical particulars, and not the transcending generalities they have always been assumed to be.

Let me then go to the first point—backreading as the only way we have looked at or tried to understand animals. First let me point out that there is limited legitimacy to this tactic on occasion, because genuine homology exists between humans and other creatures. That is, we are animals, and we are evolved from other animals, and we do have varying degrees of kinship with animals. And, as you know, evolutionary biologists make a key distinction when judging similarities that exist among different organisms, into homology and analogy.
Analogies are similarities held because evolution has produced, independently, pretty much the same form over and over again: the wing of a bat; the wing of a bird; the wing of an insect; the wing of a pterosaur. These are analogous features, because the common ancestor for any pair of these creatures had no wings—and the wings evolved separately in each lineage. Homologies are traits shared by common descent. The bones in the arm of the whale, the horse, the bat, and me are effectively the same topologically, but the whale swims, the bat flies, the horse runs and I gesture. Clearly, this is not a result of separate evolution for common function, but is a tie to history. We all have the same bones because we have common ancestors in mammals, which have this configuration.

For evolutionary biologists, homology has primacy. Homological similarity—similarity by history and descent—is overwhelmingly powerful. An analogous similarity—a convergence, as we call it—can never be anything other than superficial. You cannot get independent evolution of hundreds of similar features—it is just a mathematical probability argument. If you have complex similarity, it is homologous; and homology is, therefore, deep, and fundamental, and important. Now, since we know ourselves best, if you can make a genuine argument from homology, it may not be invalid to analyze a feature in us that we understand better, because we know it from personal experience, and use that analysis to interpret animal features if they are truly homologous. This procedure is not invalid.

Let me give you my absolutely favorite example of a brilliant argument by homology—in this case more to explain humans from animal models—from the third of Darwin’s evolutionary books. All his books were evolutionary in one sense, but I like to see his great evolutionary books as a trilogy: The Origin of Species (1859); The Descent of Man (1871); and the one that deserves to be much more read, the third member of the trilogy, The Expression of the Emotions in Man and Animals (1872). An absolutely brilliant book because Darwin does what he always does so well. Intellectuals are supposed to be people with the deepest knowledge about the broadest questions. Put an intellectual on television, and he will tell you what the course of the future is going to be. But this is not right. Often the most important thing is to recognize the limits and to stick to what can be done.

The brilliance of Darwin’s book about the emotions is that he’s not trying to interpret in evolutionary terms what cannot be done—namely, the deep meaning of the emotions, their moral value, and so on. He is talking about the expression of the emotions in man and animals—that is, the physical appearance, the gestural capacities. The whole book is one brilliant argument—namely, that if you look at the universal form of those emotional expressions that are universal across human cultures—and Darwin took great pains trying to establish that universality—and you interpret these gestures by seeing their homological similarity with expressions in other mammals, then you can understand that their origin must be evolutionary, and cannot be by divine creation—because although the expressions have no functional meaning in humans—they seem arbitrary, and they do not have to mean what they universally do in other animals. When you see what the other animals are doing, those in which this expression of emotion first arose, the gesture is very functional there. And, therefore, homology is retained in human expression, even though the original purpose is no longer followed in humans.

Consider my favorite example (and I am sure Darwin is right here) rage. What do we do? We snarl; we raise the side of our lips, thereby exposing our canine teeth—which are no bigger in humans than any other teeth, and therefore not a threat at all. But in other animals the raising of the lips and the exposure of the canines shows the large dangerous teeth, as in dogs—and, therefore, the gesture makes sense in its original form. But we still do it, and this must be a homological retention.

I do not want to leave the subject of homology without
saying something about the most exciting development in evolutionary theory during the last decade—namely, the beginnings of understandings through genetic tracings of the actual course of embryological development as genetically mediated. We have found that the extent of homology is vastly greater than anyone would have thought. In 1963 Ernst Mayr, the greatest evolutionist of this generation said: It would be vain to look for any homology—that is genetic identity, similarity based on common ancestry—in the genetic sequences of genes from different phyla—such as insects and humans, to choose the obvious example—that have been separate for at least 550 million years. The attempt would be vain because we know that natural selection is so powerful and has completely altered every aspect of the genome, that whatever similarities might have once existed have clearly been wiped out by independent evolution over all that time and in such different directions.

Yet it is not so. The homologies between distant phyla are quite stunning, and often produce very similar features. If any of you saw the cover of Science recently, you will have read about remarkable experiments showing that a single gene—_eyeless_ in Drosophila—can, when expressed in a part of the body that does not normally form eyes, produce fully functional eyes. You can make them on the wing; you can make them on the tips of the antennae; you can make them on the legs—you can make them practically anywhere. Even more fascinating, the homologue of that gene in humans—called _aniridia—and in mice works just as well on the insects to produce eyes. The development of eyes in insects, in humans and in squid is the classic textbook example of convergence—that is, of independent evolution. And clearly, in an anatomical sense, this old view is correct. But it turns out that there is homological underpinning of the developmental pathway. They all carry the same _PAX-6_ gene that controls the developmental pathway for making eyes.

Let me discuss the example that has been most in the press—body segmentation in the famous homeobox story of arthropods and chordates—that is, the groups that include insects and vertebrates. It is an old argument, dating to Etienne Geoffroy Saint-Hilaire in 1830, who made an argument, which turned out to be wrong in detail, and to which he was ridiculed, that insects and vertebrates share a common structured plan based on the archtype of the vertebra—just as Goethe, his friend, had argued that the common form of plant structures is the leaf—the _Uppland_. And Geoffroy did not shy away from the strange implications of his expanded homology, which is, let's face it, that an insect—who has an external skeleton—lives inside its own vertebrae and walks on its ribs.

Now, that comparison is wrong, and people therefore threw aside the entire notion that there could be similarity in a genetic, homological sense in segmentation—until all the new discoveries—based, initially, on the so-called homeotic mutants of _Drosophila_.

The ordinary antenna of drosophila, the fruit fly, consists of two parts—the antenna and the so-called arista at the end. There are a set of odd mutations, which have been known for a long time, called the homeotic mutations, which place a body structure in a "wrong" place, so to speak. An example is _antennapedia_, in which a leg appears where an antenna ought to be. That is not as weird as it sounds, because, evolutionarily, legs and antennae are based on the same ancestral structures.

Now, about 20 years ago, Ed Lewis at Cal Tech made a brilliant suggestion and confirmed a genetic model that explained how these homeotic mutations work. This slide shows an ordinary insect as it develops: the larva is on the left, the adult fly on the right. We note a series of segments, _H_ atop his head. T1, T2 and T3 are the three segments of the thorax—that is all we have to be concerned with here. In insects, each thoracic segment bears a leg. That is why insects have six legs, because there are three thoracic segments and each bears a leg. The second thoracic segment bears a pair of
wings. Most insects have two pairs of wings, and the third thoracic segment also bears wings. In flies, which have only two wings, unlike most insects, the third thoracic segment bears a vestigial set of wings, called halteres. And then you get a bunch of abdominal segments behind.

Ed Lewis figured out that there is a wonderfully simple model for how differentiation proceeds in the right order. There are a series of genes—Drosophila has only four chromosomes; these genes are one arm of the third chromosome, and they are lined up in a row. They are products of a single ancestral gene that duplicated and put its duplicate copies right next to each other along a line. What happens is the following. The genes that produce the correct differentiation of the segments, turn on in sequence. The first gene turns on in the second thoracic segment and then is expressed all the way back. The second gene turns on further back—it turns on in A1, and then is expressed all the way further back. The third gene, number two, starts in A2 and is expressed all the way back, and so on.

The whole point of this, the only thing you have to grasp, is that this process yields a gradient, where the maximum gene product is at the back of the organism—because all of the genes are expressed in A8 (the last abdominal segment) and a minimum amount of the gene product occurs up front. Each segment differentiates according to how much of the gene product it has. Here is a simple prediction, the affirmation of which broke the dike in understanding this system: mutations that intensify the gradient—that give you more gene product than you ought to have—make posterior structures. But most mutations are so-called deletion, or loss-of-function mutations—you get less of the gradient. This means that structures that ought to be up front appear further back, because there is less gene product further back than there ought to be, and less gene product means that a segment is differentiating as though it was further forward on the body.

Now, that simple theme explains all the really weird homeotic mutations at the back end of Drosophila. The most famous of all is bithorax, the four-winged Drosophila. It looks as though it recovered an evolutionary past and has four wings again. But this is not true—for bithorax is just a loss-of-function mutation in which, because there is less gene product, the third thoracic segment—which ought to develop vestigial halteres—thinks it ought to be another second thoracic segment. And so it grows its third thoracic as though it were another second, so you have two seconds. And since seconds grow wings, you have a four-winged fly. It's not really recreating its ancestry.

And then we have an even weirder one, called bithoraxoid, the eight-legged fly. Insects have six legs. Here's one that seems to violate the definition of its class. But it is the same thing—a loss-of-function mutation. There is not enough gene product in the first abdominal segment. Therefore, it thinks—you see, we use backreading of intent-language all the time!—that is, the segment thinks it ought to differentiate as a supernumerary thoracic segment, and so it does. Instead of being a first abdominal, it differentiates as another third thoracic. The third thoracic has legs, so now we have eight legs instead of six.

So far this is just an insect story. But here is the great discovery of the last 10 years. The same genes exist in vertebrates. In fact, they exist in fourfold repetition. The whole sequence is repeated four times in vertebrates. This is probably why we do not have weird homeotic mutations in vertebrates, because there are four copies of all these genes. So if one of them mutates, the other three are still presumably expressing the normal state and can overwhelm it—whereas in insects there is only one copy, so if it mutates it expresses. But is that not stunning? I mean, Geoffroy was right after all. There is a fourfold repetition of gene clearly homologous to those of insects—they are 90 to 95 percent similar after 500 million years of separation from the insects. You might say, "Yeah, but so what? If it is differentiating segments in insects, what is it doing in vertebrates? If it is doing something totally
different, then so what." Well, it is doing something similar in vertebrates—and that is the fascinating thing.

It turns out that vertebrate backbone segments are not the same thing as insect body segments—that is where Geoffroy was wrong. But what modern scientists had forgotten is something that all the great nineteenth-century embryologists knew—that the brain, the mid and hind brain, as it differentiates in embryology, develops as a set of segments, called rhombomeres. And you might say, “But it is all erased in the adult brain.” But it is not, because the tongue structures and the cranial-nerve divisions are largely reflective of this old segmentation. In this slide, you can see four of the Hox genes—that is, the mammalian homologues of the invertebrate genes—and their anterior expression boundaries are not in the spinal column but in the rhombomeres. So, clearly, they are determining the rhombomeres, which are the homologues of the insect segments. It is just fascinating. And this slide is a mouse embryo showing that most of these genes—you can see them along the top—are expressing in the rhombomeres.

The initial vertebrates, by the way, had very small backbones—that is, the part that is not homologous—and very large gill baskets—which are the homologues, which differentiate from the rhombomeres. So the initial vertebrates in the fossil record are mostly expressing the system of segmentation that is the homologue of the insect case. It is just a fantastic story.

One last point about homology—we’ll just look at the next slide—this is one of the most poignant pictures I have ever seen. This is the gravestone of Baby Fae. You may remember her story at Loma Linda University. A baboon’s heart was engrafted into her, and she died. Something so touching—call it “vernacular art”—but the two hearts on a tombstone—her own, that failed, and the baboon heart that failed. Or is it her mother and father who love her?—I do not know. I do not want to make a big point about this, and I do not know whether she could have been saved any circumstances. Let us just say it was foolish in the extreme and not respectful of evolutionary principles, if the experiment was to be done at all, to use a baboon heart and not a chimpanzee heart. Baboons are 30 million years evolutionarily distant from humans. Immunological acceptance or rejection is a question of overall genetic similarity, which is homology. Chimpanzees are six to eight million years different. If you look at Dr. Bailey’s justification for why he did the procedure, he justified it only in functional terms. Well, a baboon heart is about the right size; chimpanzee hearts are hard to get. But then we come to the key point: Dr. Bailey is a Seventh Day Adventist—he does not believe in evolution. Sometimes, if you do not acknowledge what it is all about, you can make some tragic errors. I will leave it at that.

Although homology is a legitimate theme, there are many fallacies based on false usages of evolution. The one I have written about most in my own career is gradualism, progressionism, and continuity theories in general. Not everything is homology. Consider the chimp-language debate—I do not want to insert myself in something that I do not know a great deal about, but I think everyone would agree that many errors were made in assuming that there could be a kind of strict continuity between basically gestural systems of organisms that are close to our ancestry and our own language faculty, which is uniquely human. Many people even misread Chomsky as a quasicreationist, because he says there is no continuity. He does not mean that God put it in there. He means that what we call the language organ may have been co-opted from some other mental function. Certainly, evolution does not always work by adaptive gradualistic continuity, though this is one of its modes.

And then we have other fallacies, the main one being the supremacist, or progressionist fallacy—the paradox of seeing animals as both lesser than us, but also defined by us—or even by our arbitrary words in the examples I gave at the beginning. You would have thought, perhaps, that evolution might
have made it better, by showing kinship with animals and partnership with the earth. The argument of evolution could be used that way, but, historically, this has not been its primary weight. The notion of backreading, of lesser-than-buth-defined by, goes right through. Evolution's not the watershed that one might hope for. It ought to have been, by Freud's famous observation that all great revolutions in the history of science kick human arrogance off one pedestal after another of our claims for cosmic self-importance. First the Copernican revolution that made our place in the universe peripheral, then the Darwinian revolution that relegated us to descent from an animal world. And then, in what I like to call the least modest statement of intellectual history, his own, that taught us we did not have rational minds, by discovering the unconscious. But it does not work, because we can spin-doctor the story—that is, we can accept the Darwinian revolution—relegation to descent from an animal world, but we spin-doctor the result. The revolution is not complete, in Freud's very prescient sense, until we accept the pedestal-smashing consequences. And that is what we are not willing to do. We want to still read animals in our terms as lesser-than-although-defined-by. We want to see ourselves as the top of the heap. We want to see evolution as progressive, complexifying and sensibly leading towards us in a predictable manner. And then we can spin-doctor the Darwinian revolution to avoid the Freudian implications.

Let me very quickly talk about two preevolutionary versions—I call them “pinnacle theories” and “embodiment theories,” both of which point to the same direction. First pinnacle theories, in which we see ourselves at the top of a progressive sequence. You do not need evolutionary theory. Progressive sequence can be constructed as a static chain of being. Charles White, Regular Gradation in Man (1799), was mentioned by a previous speaker. This slide shows his main chart—in which you see a motley collection arranged in a so-called progressive sequence, from birds at the lower left, to dogs, to primates. And then up the conventional racist ladder of human groups: from African blacks, to American Indians, to Greek statuary on the right. So this scheme also clearly has social implications.

And then we have embodiment theories—not the claim that we are at the pinnacle, but that all the lower creatures are imperfect embodiments of us. Now, the most wonderful example of that theory occurs among the German Naturphilosophen of the early nineteenth century. I did a study of Lorenz Oken in my book Ontogeny and Phylogeny, who published his Lehrbuch der Naturphilosophie between 1809 and 1811, and his theory is based upon a this marvelous notion. The whole book, this very thick book, is nothing but a series of 4,000 oracular pronouncements. And the basic notion is that all development begins with a primal zero and progresses to complexity by the successive addition of organs in a determined sequence. The sequence of additions follows Oken's ordering of the four Greek elements—earth processes, or nutritive organs, first; water processes, or digestion, second; air processes, respiration, third; and ether, or fire processes motion—fourth. "Man"—his word—contains all the organs within himself, thus, he represents the entire world—because all the organs are in humans. Quoting now: "In the profoundest, truest sense, a microcosm. Man is the summit, the crown of nature's development, and must comprehend everything that had preceded him. In a word, man must represent the whole world in miniature. All lower animals, as imperfect or incomplete humans, contain fewer than the total set of organs. "The animal kingdom"—this is the most famous pronouncement in the Lehrbuch—"is only a dismemberment of the highest animal—that is, of man."

And then, just as White invokes the racial implications, let me read you the closing oracular pronouncements. Now, poor Oken was just a romantic liberal, but you can see how notions like this can be used for other German social philosophies that came after him. He talks about the sequential ordering of
human skills. "The first science is the science of language, the architecture of science, the earth." (I am not saying that any of this makes sense, I am just quoting.) "The second science is the art of rhetoric—the sculpture of science, the river"—in other words, water. Remember the sequence—earth, water, air, fire. "The third science is philosophy, the painting of science—the breath"—air. "The fourth science is the art of war [Kriegskunst]—the art of motion, dance, music, the poetry of science, the light"—fire. "As all arts are united in poetry, so are all arts and sciences united in the art of war. The art of war is the highest, the most exalted, the most godly [gottliche] art. The hero [der Held] is the highest man. The hero is the god of mankind. Through the hero is mankind free. The hero is the prince—the hero is God." That is how the book ends.

And then, of course, we also encounter the myth of meliorism in our interpretations—namely, that once you get to the evolutionary interpretation, or at least get towards it, things ought to be better, right?—because now we are getting closer to a truthful biological theory. So we come to Linnaeus, who is not yet an evolutionist but at least is trying to place humans into nature.

Consider the wonderful story of Linnaeus's coining of the term "mammal." This is not my argument—it comes from Londa Schiebinger, whose book on the subject impressed me greatly. I knew before I read her work, that Linnaeus had invented the term "Mammalia" for our vertebrate class in the Systemae Naturae of 1758, but I thought that he had simply promoted an old vernacular word to a new technical meaning. However, Londa showed that Linnaeus truly invented the word—that no language had ever before referred to the group of warm-blooded, hair-sporting, live-bearing vertebrates as mammals. All previous systems had treated and named our relatives differently. Aristotle had established a vertebrate group called Quadrupedia—four legs—with a primary subdivision into Oviparia, scaly and egg-laying—including reptiles and some amphibians—and Viviparia—that is, hair and live-bearing—thus including most mammals but, please remember, excluding such creatures as bats, whales and, most importantly, humans—who thus could remain separate. By Linnaeus' time, our group had a better definition but no recognized name. John Ray, for example, the greatest of Linnaeus' predecessors, had suggested Pilosa—meaning hairy—as a way of annexing obviously related animals that did not exhibit Aristotle's defining feature of four legs.

So why did Linnaeus choose a new name? And why, particularly, did he choose such a peculiar term as Mammalia—referring, obviously to the female breast? We must grasp the extreme unconventionality of Linnaeus' decision. Most generally, and for the usual sexist reasons, we tend to personify active phenomena as male, and organisms judged most complex should ordinarily fall under this sad convention. By the way, in contemporary English we still invariably refer to an unsexed animal as he—as in, "Isn't he cute?" or "Look at him go!" If Linnaeus had been an explicit egalitarian out to sink a bad habit by example—he might have chosen Mammalia for this overt political reason. But Linnaeus was a social conservative and a conventional sexist. More particularly, zoologists have long translated this general cultural convention into technical practice. Do you realize that in formal taxonomy it is still stated that the so-called type specimen—that is, the defining name-bearer for a species—has to be male? That is still a rule of biological naming.

Why, then, did Linnaeus choose a female trait to define the highest group—apparently adding insult to male injury by selecting a feature that males also possess, but in a rudimentary and useless state? Schiebinger argues cogently that Linnaeus made this decision for an ideological reason, one very distant from any notion of sexual equality. Linnaeus had been deeply engaged in a different and equally important battle—this time, or so most of us would judge today, on the right side: namely, his campaign to classify humans into nature with other animals at a time when many naturalists still insisted
on a separate human kingdom for beings with a soul, and created in God's image. Our propagandists have always recognized that an adroit choice of name can convey great power of persuasion. Nature has almost invariably been personified as female, in a cultural and linguistic tradition that dates at least to Chaucer. If one wishes to gain some rhetorical advantage in a struggle to place humans within nature, then choose a female feature to define our larger group—thereby emphasizing our closeness to Mother Earth and her other animate productions. Interestingly, in the same work that defined our larger group as within nature, Linnaeus sought to separate us as a species for our mental prowess, and here he chose a male designation: Homo sapiens—although the Latin "Homo," I realize, may be taken more generally in the old sense of humankind, while vir is more specifically a male person—from which we obtain, by the way, and for sexist reasons, the notions of virtue—although the word is feminine in most European languages—and virility.

So Linnaeus is a step in the right direction in the meliorist tradition, and Darwin is the next step in melioration because he finally got us to evolutionary theory. Everything should now be right and factual; our biased way of treating animals in human terms should now cease. But it does not work. It does not work in the small, and it does not work in the grand. I want to give two examples—a small example of the errors we still make for a particular case, and then a large example in how we look at the whole history of life.

This slide shows a study done by a colleague of mine in the sociobiological research tradition. I want to criticize his backreading of human traits into animals, not his sociobiology per se. Let me just tell you what he did. This is meant to be a study of the adaptive meaning of a behavior in mountain bluebirds. He took two nests. The females tend to sit at the nest, the males go out foraging for food. While the males were out foraging, he took a stuffed male and placed it by the nest, and saw what the returning male would do. Would the returning male be aggressive to this presumed potential imposter, and would he be aggressive to the female?

Now, on the vertical axis of the graph we see the number of aggressive encounters towards the male stuffed bird (the model) and toward the female. My colleague did this procedure at various times. He did it for the first time—that is, exposed the stuffed bird—after the nest was begun but before any eggs had been laid, and there were a lot of aggressive encounters. In fact, in one case the female was thrown out of the nest. Then, after the eggs were laid, he did it again, and he found fewer aggressive approaches towards the stuffed bird, and none towards the female. And then he did it the last time, after hatching of the eggs, and found even fewer aggressive encounters towards the supposed intruder.

I want to read you his interpretation of this, because it is such an amazing example of how we read human traits into our language, and then rederive them: "The results are consistent with the expectations of evolutionary theory. Thus, aggression toward an intruding male, the model, would clearly be especially advantageous early in the breeding season, when territories and nests are normally defended. The initial aggressive response to the mated female is also adaptive, in that given a situation suggesting a high probability of adultery the presence of the model near the female—and assuming that replacement females are available—obtaining a new mate would enhance the fitness of males." You see the point. As a good Darwinian male bluebird, you do not want to lose this female who raises someone else's genes. However, after the eggs are laid, the pressure of other males ceases to matter, because you know your genes are in there, if you have been watching carefully before.

So he goes on, and his explanation could be right. It is just the language I am talking about. "The decline in male-female aggressiveness during incubation and fledgling stages could be attributed to the impossibility of being cuckolded . . ." (Now, is this not wonderful? Here is a word that, of course, comes from
animals—cuckoos—is then used in a human sense and is now being reimposed on other birds.) "... the impossibility of being cuckolded after the eggs have been laid."

This is a particularly good example, because it is so obviously subject to the following different interpretation: The model—that is, the stuffed bird—is exposed for the first time. The male comes back, pecks at the stuffed bird, and gets mad at the female, too. Then, a few days later, the same returning male encounters the stuffed bird, pecks at the stuffed bird a few times and says to himself: "It's that goddamned stuffed bird again"—I am backreading, too, you see—and he does not bother the female. It does not have to have anything to do with genetic adaptive behaviors.

Now for my example in the large. We still view the entire history of life as a grand backreading. We see this whole history of life as predictably preparatory to us. We see all previous creatures as precursors, or avatars, of the eventual appearance of humans.

[At this point in the talk, I presented a long series of slides showing our conventional iconographies of evolution as progressive sequences leading to Homo sapiens and therefore defined by the predictability of our eventual and inevitable appearance. I showed several different versions from a wide variety of times and cultures, from pre-evolutionary Biblical natural histories of the early eighteenth century (the progressive sequence of Genesis leading from initial chaos to Adam and Eve) to modern advertising (the evolution of computers from a hairy ape bent over from the weight of holding an old vacuum tube computer to a white male in a business suit [thereby encoding other iconographic biases of our culture] standing straight and tall because he only has to hold a light power book).]

Now for the second part of the talk. We, as Protagoras said, regard ourselves as the measure of all things, so that even the most abstract and universal issues of science and philosophy are often backread from desires to assert our primacy. Thus, many of the great timeless abstractions of philosophy really arise from the contingent history of us. A great dichotomy pervades the sciences, as popularly understood. One kind of science represents the stereotype we all learned—science is experimental, predictive, quantitative. You simplify and bring material into a controlled laboratory. You make predictive statements. You find out the laws of nature. This is good, or hard, science. But other scientists are, in a sense, relegated to explaining those uniquenesses that can occur but once in all the detailed glory of history—much of cosmology, evolution, geology, paleontology—and these are the lesser, or the soft sciences. The hierarchy goes from adamantine physics at top to squishy subjects like psychology at the bottom. I feel some affinity to this bottom, because paleontology is regarded as pretty squishy, too.

At Harvard, we actually set up our science curriculum in the general-education program, the core curriculum, in a somewhat innovative way. We did not just make the standard division into natural and physical sciences, or physical and social sciences. We actually recognized these two styles, the historical-predictive and the historical-explanatory. We called them A and B, and guess which one was A?

Well, as a member, and proud of it, of one of the B sciences, paleontology, I've tried to institute something of a campaign to get people to recognize the virtues, the excitement, the power, the equal explanatory role of the sciences of contingency. That is, the sciences that are not trying to explain things by subsumption and prediction from nature's laws, but by the actual sequence of the antecedent states that happened to occur, but could have unfolded in a totally different manner, thus leading to an entirely different outcome. This is a very different mode of explanation, but when you have enough evidence about antecedent states, it is just as powerful, just as good.

The point I want to make—and this is a quick summary of the arguments in my book, Wonderful Life—is that humans.
though we have tried to interpret our origin under the predictive models of the A sciences—hence, all our iconography of depicting evolution as something that was, if not bound to occur in exactly this form, is at least expectable and understandable under nature’s law of evolution as complexification. But evolution does not work in this way at all. We are products of a contingent history. Rewind the tape of life to the early history of multicellular forms, and you get a whole different set of solutions every time—most of which, although equally explainable, do not include the origin of any self-conscious creature to have conferences like this.

We are quite comfortable with contingentist explanations for human history. We know that they apply to our affairs. This slide shows the Angle of Gettysburg, the clump of trees towards which Robert E. Lee directed his men in Pickett’s Charge. The power of Gettysburg for us lies in our knowledge that the war could have gone the other way. It was not foreordained by the strength of their army that the Union would win. July 4th, 1863 was a very crucial time—though Vicksburg fell to Grant on the same day. Draft riots were about to break out in New York. And in my city of Boston, the 54th regiment of black volunteers was being armed—not for any abstract sense of racial justice, but for a desperate need for bodies. Northern victory was not assured. Had the Civil War been, as MacPherson argues, a war of conquest, the South could not have conquered the North, but it was not this kind of war. The South’s aim was simply to hold on long enough to induce sufficient warweariness to get the North to recognize its boundaries—and this almost happened. MacPherson argues powerfully that at least up until the reelection of Lincoln in 1864, the war could easily have gone the other way. And we know why the South lost at Gettysburg as a result of a whole set of events and errors: Not taking the high ground in the beginning; Chamberlain and his Maine division holding Little Round Top; Lee thinking that the Northern battery had gone silent because his guns had knocked it out. Lee knew he had made a total mistake the minute he heard the Union cannons firing on his men. We know why the South lost at Gettysburg, but the explanations are not laws of nature—they are particulars of history. The battle could have gone the other way, and all of American history might have been different.

We are comfortable with this mode of explanation for human history. We should be just as comfortable for life’s history, and for our own origin as human beings. But, unfortunately, the other viewpoint is encoded into our iconography. We see the history of life as a cone of increasing diversity. From a common point of origin, a correct view under evolutionary theory, lineages move up and out. The cone is very narrow at the base, so you can only have a few lineages at the start, and these must be predictably preparatory to the ones that come later. Up is only supposed to mean geologically younger, but it is so easy to conflate up with higher on the ladder of being, and so things move up and out towards necessary progress and diversification. This slide shows the first great tree of life—from Ernst Haeckel, 1866. Let me show you why it is a biased iconography, in case you never recognized this. The problem is that you’re forced to put at the top, where there’s most space, the group that you think is maximally advanced. But what if that group is not very diverse, as in this case? Haeckel took the conventional view that mammals are most advanced. But there are only 4,000 species of mammals—not very many. There are a million described species of insects. Haeckel spreads mammals across the entire top of the tree. But all of insects, all of those million species, lie on one little branch down here. One little branch, because that is all the room he has lower down on the cone, in the region of low zoological status, where insects must share a limited space with other groups. This is a biased iconography that promotes the predictabilist, meliorative view. That is why its replacement by another iconography is so vital.

I suggested an alternate iconography in *Wonderful Life* as shown on the next slide. Note that you still have a common
point of ancestry, but then a maximal spread of lineages occurs very early in history. And only a few of the initial possibilities survive, though these few may be enormously successful, and you may end up with more species than you ever had but restricted to far fewer anatomical groups. Now, this pattern is subject to a conventional predictabilist reading—namely, there was a grand struggle for Darwinian reasons during this early period and the good guys won. But this new picture is also subject, as the conventional iconography is not, to a radically different contingency-based explanation, in which each initial group only gets a lottery ticket in the greatest lottery ever held on the history of this planet. The survivors are effectively those who were fortunate. And I think that the evidence of the Burgess Shale, the great soft-bodied fauna from the early days of life’s history, supports this point of view. I do not have time to give you the rationale but only to show you some of the organisms.

In this one fauna, from the early history of multicellular life, 530 million years ago in Western Canada, we have greater diversity than in all modern oceans put together. Arthropods today represent 80 percent of animal species. There are three major groups of arthropods today: the insect group, the spider-scorpion group, and the marine group—crustaceans: lobsters, shrimp, barnacles, and so on. Moreover, we do not know why the creatures died out. I recognize the limits of negative evidence, but we have no argument that the ones who survived did so for cause in the conventional sense of predictable superiority.

The Burgess Shale also includes a very insignificant creature named Pikaia, the one name you might want to remember because Pikaia is the first chordate, the first known member of our phylum. I do not say it’s the only chordate living, and I do not say Pikaia is our direct ancestor. But if you had been an impartial observer 530 million years ago, I do not think you would have identified the chordates as a group with enormous probability of success. If, like most groups in this lottery, they had died, all of vertebrate history would have been wiped out of the fossil record. All of us—from trout to hippopotamuses to all humans.

The theme of contingency is fractal. It does not only work at this grandest level—it works down to every sequence of scales. An asteroid wiped out the dinosaurs 65 million years ago. If it did not hit, we would still be in a world of dinosaurs, and mammals would probably still be little creatures in the interstices of their world. Why not? That situation had prevailed for 100 million years before. It’s only been 65 million years since.

Last point. The most abstract questions of science and philosophy are really about human beings as historical particulars. That is why we have struggled with these issues, and that is why we still grapple with them today. Since we are historical particulars, some of these grand questions—though we frame them as universals—really turn out to be inquiries about an individual pathway of history. Descartes starts with a whole series of pictures illuminating bodies as la machine—that is, humans shown as mechanical devices for the eyes, the hands, and so on. But as soon as he gets to the brain, every picture shows the pineal organ—the seat of the soul and its dualistic mediation of the material aspects of reality outside.

Is there any deeper philosophical tradition than dualism? This is John Milton, Il Penseroso: O, let my lamp at midnight hour / Be seen in some high lonely tower / Where I may orl 0111 watch The Bear [that is, the plow or the Big Dipper] or unsphere the spirit of Plato / to unfold what worlds / or what vast regions hold / the immortal mind that hath forsook / 

mansion in this fleshly nook. Is this not a great image? The immortal mind’s spirit which has forsaken its mansion in this fleshly nook, and can soar up into and with the stars. Dualism is really an inquiry about us and why we are superior.

Theology—where it’s clearer, perhaps, that all these great issues are about us. The two versions of creation in Genesis—the sequential story of Genesis 1; and the second
story of Genesis 2, where the animals are brought to Adam, and he is given the power to name them. Genesis 1, the conventional story of the days of creation, is subject to two quite different interpretations, but both united by putting humans on top. First, the traditional interpretation—which I think is wrong—an additive sequence: First, God makes the earth, then the firmament, then the plants, then the animals. Then consider the alternative model, which I think is right but is hard for us to see, because we are living with different presuppositions—that Genesis 1 really talks about successive divisions and differentiation from an initial, or primary, chaos. If you look at the mosaics in the south dome of the narthex of San Marco’s Cathedral, you will see this alternative iconography. First there is chaos filling the whole space, then a division of light and darkness, then the firmament from the earth. Here we encounter an old paradox: How can there be light and darkness before there’s a sun and a moon? Of course there can, because the sun versus the moon represents a later division within the realm of light—one for the night and one for the day. And then the earth brings things forth—that is, there is a differentiation of the earth into its waters and its plants, and so it goes. And finally, the ultimate sexist differentiation—Eve comes from Adam.

Conclusion: How do we transcend all this? How do we get to the possibility of partnership and respect as better models for our relationship with animals? I do not know, but, for one thing, we need a new iconography. That is one humble suggestion I can make. Go to the newly revised mammal hall at the Museum of Natural History, because they have done a brilliant thing. Virtually every evolution hall in the world shows organisms in a conventional linear sequence. If there is a hall of mammals, primates are at the end. And nobody ever questions that—because there is a linear order through the hall. You go to the new hall and primates are in the middle. And you are bound to wonder and ask: “Now, why are primates in the middle, next to bats and other creatures like that.” Ah! They are ordering the hall by branching sequence, not supposed progress. Primates are part of a lineage that branched off from the main line of mammals early in our history. If you arrange creatures by the order of branching sequence, primates come early. This new and unconventional arrangement really gets you thinking.

But why do we do usually proceed by backreading? I think that we act primarily from fear. We are so afraid that maybe we are insignificant that we have to spin-doctor evolution in our form. The greatest document for this issue, by the way, is Psalm 8, not Genesis 1. Psalm 8—the expression of fear, first of all: “When I consider thy heavens, the work of thy fingers, the moon and the stars which thou hast ordained, what is man, that thou art mindful of him?” And how could human life mean anything in the face of the vast heavens? The answer in Psalm 8: “For thou hast made him a little lower than the angels, and hast crowned him with glory and honor. Thou madest him to have dominion over the works of thy hands. Thou hast put all things under his feet. All sheep and oxen, yea, and the beasts of the field, the fowl of the air and the fish of the sea, and whatsoever passeth through the paths of the sea. O Lord, our Lord, how excellent is thy name in all the earth?”

Now, contrast this conventional hubris with Darwin’s answer to the same question: What is man? Consider a wonderful letter that he wrote to Asa Gray in 1860, after Gray had written to him and said: Look, Darwin, I can accept the principle of natural selection—it makes sense—but I cannot avoid the conclusion that there must be some deep God-given meaning to the totality. Darwin writes back: You may be right. Science cannot adjudicate big issues like this. But, he says, even if that is so for the unknowable totality, “the details, whether good or bad” must be “left to the workings out of what we may call chance”—by which he does not mean chance in the technical sense of randomness. He means contingency, as I use the term. That is clear from the rest of the argument.
He then goes on to make a brilliant set of points, trying to lead Gray towards the position that we are an accident, a contingent part of history. He says: Look, Gray, if a man is caught in a thunderstorm on top of a mountain, is hit by lightning and dies, he died for a reason, based on the physics of lightning. But no one would say that his death was meant to be in some cosmic sense. It was an accident that he was on the mountain. So we have contingency for the death of an individual. How about the birth of an individual? A child is born with terrible mental retardation. This undoubtedly occurred for some reason not yet understood in the mechanics of development and embryology. But no one, if God be just, would claim that this situation was meant to be. It happened; it was an accident. Contingency then for individual life and death. How about the death of a species? Death of a species is also by accident; species become extinct. If the death of species is an accident—then the birth of a species should be viewed as an accident, too. And humans are species, like all others. So, from the death of a man by lightning on a mountain, which is clearly due to contingency, Darwin has subtly led Gray towards an acceptance of human origin as one of life's contingent details. Remember what he said: "With the details, whether good or bad, being left to the workings out of what we may call chance." The realm of details is enormous, and it includes the human species. I suggest to you that it also includes most of the grand questions of philosophy, politics, and so forth.

I want to end with my favorite sonnet from Frost, because it is such a brilliant statement about the problem of design or intent in nature. So many horrible things occur in nature. If we have to say they are a result of design, how can we honor anything? Frost answers that they are not—they are details in the realm of contingency.

The poet is taking a walk, and he notices a remarkable scene. He sees a heal-all, a flower, which is usually blue. But this one is white, so that is rare. And on the flower he sees the wings of a moth that has been eaten, and they are white, too. The moth has been eaten by a white spider—a rarity as well and the spider is still there. So the poet notes three white objects, each with a different geometry: the starburst of the flower; the solidity of the spider; the two-dimensional structure of the moth wings. This must have some general meaning three white things of different geometries, all together? And yet, if it has meaning, what meaning could be expressed? The moth has been eaten—it is a horrible scene. So Frost writes:

I found a dimpled spider fat and white
On a white heal-all, holding up a moth
Like a white piece of rigid satin cloth.
Assorted characters of death and blight

Mixed ready to begin the morning right
Like the ingredients of a witch's broth:
A snow-drop spider, a flower like a froth
And dead wings carried like a paper kite.

What had that flower to do with being white?
The wayside blue and innocent heal-all.
What brought the kindred spider to that height,
Then steered the white moth thither in the night?

What but design of darkness to appal
If design governed in a thing so small.

You see, the point is that *Homo sapiens*—and this goes back to Darwin on Gray—is also a "thing so small" in a vast universe—a wildly improbable evolutionary event well within the realm of contingency. Make of such a conclusion what you will. Some find the prospect depressing. I have always regarded it as exhilarating and a source of both freedom and consequent moral responsibility toward other animals as well as fellow humans. Thank you.