

The Panda's Thumb

More
Reflections
in Natural
History

Stephen Jay Gould



W · W · NORTON & COMPANY
NEW YORK LONDON

Copyright © 1980 by Stephen Jay Gould.
All rights reserved.

Printed in the United States of America.

First published as a Norton paperback 1980; reissued 1992.

Library of Congress Cataloging in Publication Data

Gould, Stephen Jay.

The panda's thumb.

Bibliography: p.

Includes index.

1. Evolution—History. 2. Natural selection—
History. I. Title.

QH361.G66 1980 575.01'62 80-15952

ISBN 0-393-30819-7

W. W. Norton & Company, Inc.

500 Fifth Avenue, New York, N. Y. 10110

www.wwnorton.com

W. W. Norton & Company Ltd.

Castle House, 75/76 Wells Street, London W1T 3QT

234567890

1 | Perfection and Imperfection: A Trilogy on a Panda's Thumb

1 | The Panda's Thumb

FEW HEROES LOWER their sights in the prime of their lives; triumph leads inexorably on, often to destruction. Alexander wept because he had no new worlds to conquer; Napoleon, overextended, sealed his doom in the depth of a Russian winter. But Charles Darwin did not follow the *Origin of Species* (1859) with a general defense of natural selection or with its evident extension to human evolution (he waited until 1871 to publish *The Descent of Man*). Instead, he wrote his most obscure work, a book entitled: *On the Various Contrivances by Which British and Foreign Orchids Are Fertilized by Insects* (1862).

Darwin's many excursions into the minutiae of natural history—he wrote a taxonomy of barnacles, a book on climbing plants, and a treatise on the formation of vegetable mold by earthworms—won him an undeserved reputation as an old-fashioned, somewhat doddering describer of curious plants and animals, a man who had one lucky insight at the right time. A rash of Darwinian scholarship has laid this myth firmly to rest during the past twenty years (see essay 2). Before then, one prominent scholar spoke for many ill-informed colleagues when he judged Darwin as a “poor joiner of ideas . . . a man who does not belong with the great thinkers.”

In fact, each of Darwin's books played its part in the grand and coherent scheme of his life's work—demonstrating the fact of evolution and defending natural selection as its pri-

mary mechanism. Darwin did not study orchids solely for their own sake. Michael Ghiselin, a California biologist who finally took the trouble to read all of Darwin's books (see his *Triumph of the Darwinian Method*), has correctly identified the treatise on orchids as an important episode in Darwin's campaign for evolution.

Darwin begins his orchid book with an important evolutionary premise: continued self-fertilization is a poor strategy for long-term survival, since offspring carry only the genes of their single parent, and populations do not maintain enough variation for evolutionary flexibility in the face of environmental change. Thus, plants bearing flowers with both male and female parts usually evolve mechanisms to ensure cross-pollination. Orchids have formed an alliance with insects. They have evolved an astonishing variety of "contrivances" to attract insects, guarantee that sticky pollen adheres to their visitor, and ensure that the attached pollen comes in contact with female parts of the next orchid visited by the insect.

Darwin's book is a compendium of these contrivances, the botanical equivalent of a bestiary. And, like the medieval bestiaries, it is designed to instruct. The message is paradoxical but profound. Orchids manufacture their intricate devices from the common components of ordinary flowers, parts usually fitted for very different functions. If God had designed a beautiful machine to reflect his wisdom and power, surely he would not have used a collection of parts generally fashioned for other purposes. Orchids were not made by an ideal engineer; they are jury-rigged from a limited set of available components. Thus, they must have evolved from ordinary flowers.

Thus, the paradox, and the common theme of this trilogy of essays: Our textbooks like to illustrate evolution with examples of optimal design—nearly perfect mimicry of a dead leaf by a butterfly or of a poisonous species by a palatable relative. But ideal design is a lousy argument for evolution, for it mimics the postulated action of an omnipotent creator. Odd arrangements and funny solutions are the proof of evolution—paths that a sensible God would never

tread but that a natural process, constrained by history, follows perforce. No one understood this better than Darwin. Ernst Mayr has shown how Darwin, in defending evolution, consistently turned to organic parts and geographic distributions that make the least sense. Which brings me to the giant panda and its "thumb."

Giant pandas are peculiar bears, members of the order Carnivora. Conventional bears are the most omnivorous representatives of their order, but pandas have restricted this catholicity of taste in the other direction—they belie the name of their order by subsisting almost entirely on bamboo. They live in dense forests of bamboo at high elevations in the mountains of western China. There they sit, largely unthreatened by predators, munching bamboo ten to twelve hours each day.

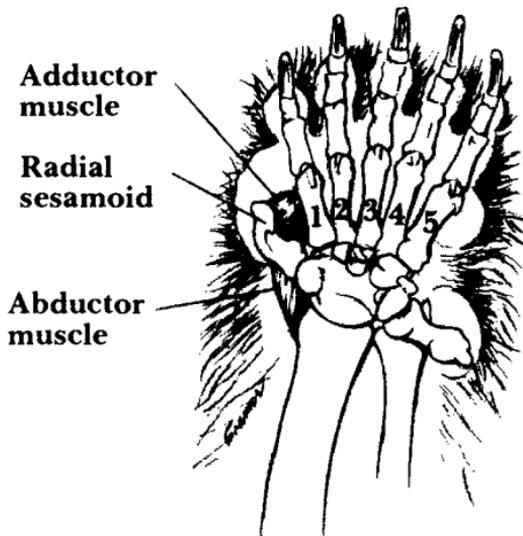
As a childhood fan of Andy Panda, and former owner of a stuffed toy won by some fluke when all the milk bottles actually tumbled at the county fair, I was delighted when the first fruits of our thaw with China went beyond ping pong to the shipment of two pandas to the Washington zoo. I went and watched in appropriate awe. They yawned, stretched, and ambled a bit, but they spent nearly all their time feeding on their beloved bamboo. They sat upright and manipulated the stalks with their forepaws, shedding the leaves and consuming only the shoots.

I was amazed by their dexterity and wondered how the scion of a stock adapted for running could use its hands so adroitly. They held the stalks of bamboo in their paws and stripped off the leaves by passing the stalks between an apparently flexible thumb and the remaining fingers. This puzzled me. I had learned that a dexterous, opposable thumb stood among the hallmarks of human success. We had maintained, even exaggerated, this important flexibility of our primate forebears, while most mammals had sacrificed it in specializing their digits. Carnivores run, stab, and scratch. My cat may manipulate me psychologically, but he'll never type or play the piano.

So I counted the panda's other digits and received an even greater surprise: there were five, not four. Was the

“thumb” a separately evolved sixth finger? Fortunately, the giant panda has its bible, a monograph by D. Dwight Davis, late curator of vertebrate anatomy at Chicago’s Field Museum of Natural History. It is probably the greatest work of modern evolutionary comparative anatomy, and it contains more than anyone would ever want to know about pandas. Davis had the answer, of course.

The panda’s “thumb” is not, anatomically, a finger at all. It is constructed from a bone called the radial sesamoid, normally a small component of the wrist. In pandas, the radial sesamoid is greatly enlarged and elongated until it almost equals the metapodial bones of the true digits in length. The radial sesamoid underlies a pad on the panda’s forepaw; the five digits form the framework of another pad, the palmar. A shallow furrow separates the two pads and serves as a channelway for bamboo stalks.



D. L. CRAMER

The panda’s thumb comes equipped not only with a bone to give it strength but also with muscles to sustain its agility. These muscles, like the radial sesamoid bone itself, did not arise *de novo*. Like the parts of Darwin’s orchids, they are familiar bits of anatomy remodeled for a new function. The abductor of the radial sesamoid (the muscle that pulls it away from the true digits) bears the formidable name *abduc-*

tor pollicis longus ("the long abductor of the thumb"—*pollicis* is the genitive of *pollex*, Latin for "thumb"). Its name is a giveaway. In other carnivores, this muscle attaches to the first digit, or true thumb. Two shorter muscles run between the radial sesamoid and the pollex. They pull the sesamoid "thumb" towards the true digits.

Does the anatomy of other carnivores give us any clue to the origin of this odd arrangement in pandas? Davis points out that ordinary bears and raccoons, the closest relatives of giant pandas, far surpass all other carnivores in using their forelegs for manipulating objects in feeding. Pardon the backward metaphor, but pandas, thanks to their ancestry, began with a leg up for evolving greater dexterity in feeding. Moreover, ordinary bears already have a slightly enlarged radial sesamoid.

In most carnivores, the same muscles that move the radial sesamoid in pandas attach exclusively to the base of the pollex, or true thumb. But in ordinary bears, the long abductor muscle ends in two tendons: one inserts into the base of the thumb as in most carnivores, but the other attaches to the radial sesamoid. The two shorter muscles also attach, in part, to the radial sesamoid in bears. "Thus," Davis concludes, "the musculature for operating this remarkable new mechanism—functionally a new digit—required no intrinsic change from conditions already present in the panda's closest relatives, the bears. Furthermore, it appears that the whole sequence of events in the musculature follows automatically from simple hypertrophy of the sesamoid bone."

The sesamoid thumb of pandas is a complex structure formed by marked enlargement of a bone and an extensive rearrangement of musculature. Yet Davis argues that the entire apparatus arose as a mechanical response to growth of the radial sesamoid itself. Muscles shifted because the enlarged bone blocked them short of their original sites. Moreover, Davis postulates that the enlarged radial sesamoid may have been fashioned by a simple genetic change, perhaps a single mutation affecting the timing and rate of growth.

In a panda's foot, the counterpart of the radial sesamoid, called the tibial sesamoid, is also enlarged, although not so much as the radial sesamoid. Yet the tibial sesamoid supports no new digit, and its increased size confers no advantage, so far as we know. Davis argues that the coordinated increase of both bones, in response to natural selection upon one alone, probably reflects a simple kind of genetic change. Repeated parts of the body are not fashioned by the action of individual genes—there is no gene “for” your thumb, another for your big toe, or a third for your pinky. Repeated parts are coordinated in development; selection for a change in one element causes a corresponding modification in others. It may be genetically more complex to enlarge a thumb and *not* to modify a big toe, than to increase both together. (In the first case, a general coordination must be broken, the thumb favored separately, and correlated increase of related structures suppressed. In the second, a single gene may increase the rate of growth in a field regulating the development of corresponding digits.)

The panda's thumb provides an elegant zoological counterpart to Darwin's orchids. An engineer's best solution is debarred by history. The panda's true thumb is committed to another role, too specialized for a different function to become an opposable, manipulating digit. So the panda must use parts on hand and settle for an enlarged wrist bone and a somewhat clumsy, but quite workable, solution. The sesamoid thumb wins no prize in an engineer's derby. It is, to use Michael Ghiselin's phrase, a contraption, not a lovely contrivance. But it does its job and excites our imagination all the more because it builds on such improbable foundations.

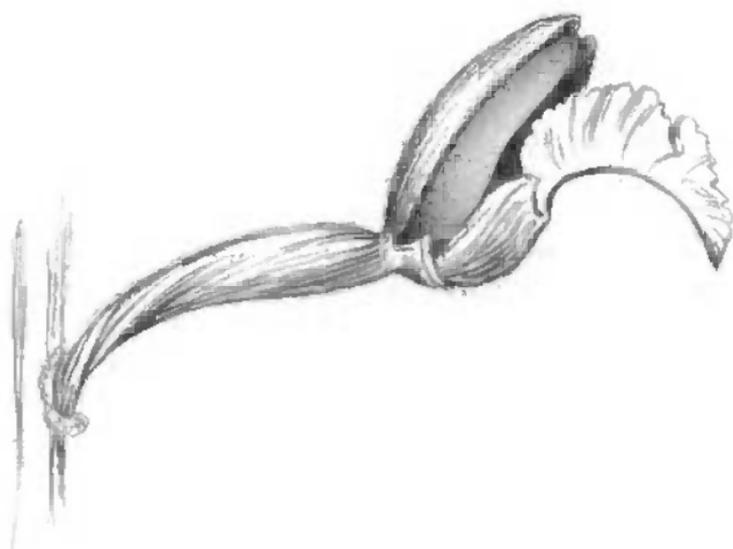
Darwin's orchid book is filled with similar illustrations. The marsh *Epipactus*, for example, uses its labellum—an enlarged petal—as a trap. The labellum is divided into two parts. One, near the flower's base, forms a large cup filled with nectar—the object of an insect's visit. The other, near the flower's edge, forms a sort of landing stage. An insect alighting on this runway depresses it and thus gains entrance to the nectar cup beyond. It enters the cup, but the

Marsh *Epipactis*, lower sepals removed



a. Runway of labellum depressed after insect lands.

D. L. CRAMER



b. Runway of labellum raised after insect crawls into cup below.

D. L. CRAMER

runway is so elastic that it instantly springs up, trapping the insect within the nectar cup. The insect must then back out through the only available exit—a path that forces it to brush against the pollen masses. A remarkable machine but all developed from a conventional petal, a part readily available in an orchid's ancestor.

Darwin then shows how the same labellum in other orchids evolves into a series of ingenious devices to ensure cross-fertilization. It may develop a complex fold that forces an insect to detour its proboscis around and past the pollen masses in order to reach nectar. It may contain deep channels or guiding ridges that lead insects both to nectar and pollen. The channels sometimes form a tunnel, producing a tubular flower. All these adaptations have been built from a part that began as a conventional petal in some ancestral form. Yet nature can do so much with so little that it displays, in Darwin's words, "a prodigality of resources for gaining the very same end, namely, the fertilization of one flower by pollen from another plant."

Darwin's metaphor for organic form reflects his sense of wonder that evolution can fashion such a world of diversity and adequate design with such limited raw material:

Although an organ may not have been originally formed for some special purpose, if it now serves for this end we are justified in saying that it is specially contrived for it. On the same principle, if a man were to make a machine for some special purpose, but were to use old wheels, springs, and pulleys, only slightly altered, the whole machine, with all its parts, might be said to be specially contrived for that purpose. Thus throughout nature almost every part of each living being has probably served, in a slightly modified condition, for diverse purposes, and has acted in the living machinery of many ancient and distinct specific forms.

We may not be flattered by the metaphor of refurbished wheels and pulleys, but consider how well we work. Nature is, in biologist François Jacob's words, an excellent tinkerer, not a divine artificer. And who shall sit in judgment between these exemplary skills?

11

Our Greatest Evolutionary Step

IN MY PREVIOUS book, *Ever Since Darwin*, I began an essay on human evolution with these words:

New and significant prehuman fossils have been unearthed with such unrelenting frequency in recent years that the fate of any lecture notes can only be described with the watchword of a fundamentally irrational economy—planned obsolescence. Each year, when the topic comes up in my courses, I simply open my old folder and dump the contents into the nearest circular file. And here we go again.

And I'm mighty glad I wrote them, because I now want to invoke that passage to recant an argument made later in the same article.

In that essay I reported Mary Leakey's discovery (at Laetoli, thirty miles south of Olduvai Gorge in Tanzania) of the oldest known hominid fossils—teeth and jaws 3.35 to 3.75 million years old. Mary Leakey suggested (and so far as I know, still believes) that these remains should be classified in our genus, *Homo*. I therefore argued that the conventional evolutionary sequence leading from small-brained but fully erect *Australopithecus* to larger-brained *Homo* might have to be reassessed, and that the australopithecines might represent a side branch of the human evolutionary tree.

Early in 1979, newspapers blazed with reports of a new species—more ancient in time and more primitive in appearance than any other hominid fossil—*Australopithecus afarensis*, named by Don Johanson and Tim White. Could any two claims possibly be more different—Mary Leakey's argument that the oldest hominids belong to our own genus, *Homo*, and Johanson and White's decision to name a new species because the oldest hominids possess a set of apelike features shared by no other fossil hominid. Johanson and White must have discovered some new and fundamentally different bones. Not at all. Leakey and Johanson and White are arguing about the same bones. We are witnessing a debate about the interpretation of specimens, not a new discovery.

Johanson worked in the Afar region of Ethiopia from 1972 to 1977 and unearthed an outstanding series of hominid remains. The Afar specimens are 2.9 to 3.3 million years old. Premier among them is the skeleton of an australopithecine named Lucy. She is nearly 40 percent complete—much more than we have ever possessed for any individual from these early days of our history. (Most hominid fossils, even though they serve as a basis for endless speculation and elaborate storytelling, are fragments of jaws and scraps of skulls.)

Johanson and White argue that the Afar specimens and Mary Leakey's Laetoli fossils are identical in form and belong to the same species. They also point out that the Afar and Laetoli bones and teeth represent everything we know about hominids exceeding 2.5 million years in age—all the other African specimens are younger. Finally, they claim that the teeth and skull pieces of these old remains share a set of features absent in later fossils and reminiscent of apes. Thus, they assign the Laetoli and Afar remains to a new species, *A. afarensis*.

The debate is just beginning to warm up, but three opinions have already been vented. Some anthropologists, pointing to different features, regard the Afar and Laetoli specimens as members of our own genus, *Homo*. Others accept Johanson and White's conclusion that these older fossils are closer to the later south and east African *Aus-*

tralopithecus than to *Homo*. But they deny a difference sufficient to warrant a new species and prefer to include the Afar and Laetoli fossils within the species *A. africanus*, originally named for South African specimens in the 1920s. Still others agree with Johanson and White that the Afar and Laetoli fossils deserve a new name.



The palate of *Australopithecus afarensis* (center, compared with that of a modern chimpanzee (left) and a human (right)).

COURTESY OF TIM WHITE AND THE CLEVELAND MUSEUM OF NATURAL HISTORY

As a rank anatomical amateur, my opinion is worth next to nothing. Yet I must say that if a picture is worth all the words of this essay (or only half of them if you follow the traditional equation of 1 for 1,000), the palate of the Afar hominid certainly says "ape" to me. (I must also confess that the designation of *A. afarensis* supports several of my favorite prejudices. Johanson and White emphasize that the Afar and Laetoli specimens span a million years but are virtually identical. I believe that most species do not alter much during the lengthy period of their success and that most evolutionary change accumulates during very rapid events of splitting from ancestral stocks—see essays 17 and 18. Moreover, since I depict human evolution as a bush rather than a ladder, the more species the merrier. Johan-

son and White do, however, accept far more gradualism than I would advocate for later human evolution.)

Amidst all this argument about skulls, teeth, and taxonomic placement, another and far more interesting feature of the Afar remains has not been disputed. Lucy's pelvis and leg bones clearly show that *A. afarensis* walked as erect as you or I. This fact has been prominently reported by the press, but in a very misleading way. The newspapers have conveyed, almost unanimously, the idea that previous orthodoxy had viewed the evolution of larger brains and upright postures as a gradual transition in tandem, perhaps with brains leading the way—from pea-brained quadrupeds to stooping half brains to fully erect, big-brained *Homo*. The *New York Times* writes (January 1979): "The evolution of bipedalism was thought to have been a gradual process involving intermediate forerunners of modern human beings that were stooped, shuffle-gaited 'ape-men,' creatures more intelligent than apes but not as intelligent as modern human beings." Absolutely false, at least for the past fifty years of our knowledge.

We have known since australopithecines were discovered in the 1920s that these hominids had relatively small brains and fully erect posture. (*A. africanus* has a brain about one-third the volume of ours and a completely upright gait. A correction for its small body size does not remove the large discrepancy between its brain and ours.) This "anomaly" of small brain and upright posture has been a major issue in the literature for decades and wins a prominent place in all important texts.

Thus, the designation of *A. afarensis* does not establish the historical primacy of upright posture over large brains. But it does, in conjunction with two other ideas, suggest something very novel and exciting, something curiously missing from the press reports or buried amidst misinformation about the primacy of upright posture. *A. afarensis* is important because it teaches us that perfected upright gait had already been achieved nearly four million years ago. Lucy's pelvic structure indicates bipedal posture for the Afar remains, while the remarkable footprints just discovered at

Laetoli provide even more direct evidence. The later south and east African australopithecines do not extend back much further than two and a half million years. We have thus added nearly one and a half million years to the history of fully upright posture.

To explain why this addition is so important, I must break the narrative and move to the opposite end of biology—from fossils of whole animals to molecules. During the past fifteen years, students of molecular evolution have accumulated a storehouse of data on the amino acid sequences of similar enzymes and proteins in a wide variety of organisms. This information has generated a surprising result. If we take pairs of species with securely dated times of divergence from a common ancestor in the fossil record, we find that the number of amino acid differences correlates remarkably well with time since the split—the longer that two lineages have been separate, the more the molecular difference. This regularity has led to the establishment of a molecular clock to predict times of divergence for pairs of species without good fossil evidence of ancestry. To be sure, the clock does not beat with the regularity of an expensive watch—it has been called a “sloppy clock” by one of its leading supporters—but it has rarely gone completely haywire.

Darwinians were generally surprised by the clock’s regularity because natural selection should work at markedly varying rates in different lineages at different times: very rapidly in complex forms adapting to rapidly changing environments, very slowly in stable, well-adapted populations. If natural selection is the primary cause of evolution in populations, then we should not expect a good correlation between genetic change and time unless rates of selection remain fairly constant—as they should not by the argument stated above. Darwinians have escaped this anomaly by arguing that irregularities in the rate of selection smooth out over long periods of time. Selection might be intense for a few generations and virtually absent for a time thereafter, but the net change averaged over long periods could still be regular. But Darwinians have also been forced

to face the possibility that regularity of the molecular clock reflects an evolutionary process not mediated by natural selection, the random fixation of neutral mutations. (I must defer this “hot” topic to another time and more space.)

In any case, the measurement of amino acid differences between humans and living African great apes (gorillas and chimpanzees) led to the most surprising result of all. We are virtually identical for genes that have been studied, despite our pronounced morphological divergence. The average difference in amino acid sequences between humans and African apes is less than one percent (0.8 percent to be precise)—corresponding to a mere five million years since divergence from a common ancestor on the molecular clock. Allowing for the slop, Allan Wilson and Vincent Sarich, the Berkeley scientists who uncovered this anomaly, will accept six million years, but not much more. In short, if the clock is valid, *A. afarensis* is pushing very hard at the theoretical limit of hominid ancestry.

Until recently, anthropologists tended to dismiss the clock, arguing that hominids provided a genuine exception to an admitted rule. They based their skepticism about the molecular clock upon an animal called *Ramapithecus*, an African and Asian fossil known mainly from jaw fragments and ranging back to fourteen million years in age. Many anthropologists claimed that *Ramapithecus* could be placed on our side of the ape-human split—that, in other words, the divergence between hominids and apes occurred more than fourteen million years ago. But this view, based on a series of technical arguments about teeth and their proportions, has been weakening of late. Some of the strongest supporters of *Ramapithecus* as a hominid are now prepared to reassess it as an ape or as a creature near to the common ancestry of ape and human but still before the actual split. The molecular clock has been right too often to cast it aside for some tentative arguments about fragments of jaws. (I now expect to lose a \$10 bet I made with Allan Wilson a few years back. He generously gave me seven million years as a maximum for the oldest ape-human common ancestor,

but I held out for more. And while I'm not shelling out yet, I don't really expect to collect.*)

We may now put together three points to suggest a major reorientation in views about human evolution: the age and upright posture of *A. afarensis*, the ape-human split on the molecular clock, and the dethroning of *Ramapithecus* as a hominid.

We have never been able to get away from a brain-centered view of human evolution, although it has never represented more than a powerful cultural prejudice imposed upon nature. Early evolutionists argued that enlargement of the brain must have preceded any major alteration of our bodily frame. (See views of G.E. Smith in essay 10. Smith based his pro-Pitdown conviction upon an almost fanatical belief in cerebral primacy.) But *A. africanus*, upright and small brained, ended that conceit in the 1920s, as predicted by a number of astute evolutionists and philosophers, from Ernst Haeckel to Friedrich Engels. Nevertheless, "cerebral primacy," as I like to call it, still held on in altered form. Evolutionists granted the historical primacy of upright posture but conjectured that it arose at a leisurely pace and that the real discontinuity—the leap that made us fully human—occurred much later when, in an unprecedented burst of evolutionary speed, our brains tripled in size within a million years or so.

Consider the following, written ten years ago by a leading expert: "The great leap in cephalization of genus *Homo* took place within the past two million years, after some ten million years of preparatory evolution toward bipedalism, the tool-using hand, etc." Arthur Koestler has carried this view of a cerebral leap toward humanity to an unexcelled height of invalid speculation in his latest book, *Janus*. Our brain grew so fast, he argues, that the outer cerebral cortex, seat of smarts and rationality, lost control over emotive, animal centers deep within our brains. This primitive bestiality surfaces in war, murder, and other forms of mayhem.

*Jan., 1980. I just paid. Might as well start off the new decade right.

I believe that we must reassess fundamentally the relative importance we have assigned to upright posture and increase in brain size as determinants of human evolution. We have viewed upright posture as an easily accomplished, gradual trend and increase in brain size as a surprisingly rapid discontinuity—something special both in its evolutionary mode and the magnitude of its effect. I wish to suggest a diametrically opposite view. Upright posture is the surprise, the difficult event, the rapid and fundamental reconstruction of our anatomy. The subsequent enlargement of our brain is, in anatomical terms, a secondary epiphenomenon, an easy transformation embedded in a general pattern of human evolution.

Six million years ago at most, if the molecular clock runs true (and Wilson and Sarich would prefer five), we shared our last common ancestor with gorillas and chimps. Presumably, this creature walked primarily on all fours, although it may have moved about on two legs as well, as apes and many monkeys do today. Little more than a million years later, our ancestors were as bipedal as you or I. This, not later enlargement of the brain, was the great punctuation in human evolution.

Bipedalism is no easy accomplishment. It requires a fundamental reconstruction of our anatomy, particularly of the foot and pelvis. Moreover, it represents an anatomical reconstruction outside the general pattern of human evolution. As I argue in essay 9, through the agency of Mickey Mouse, humans are neotenic—we have evolved by retaining juvenile features of our ancestors. Our large brains, small jaws, and a host of other features, ranging from distribution of bodily hair to ventral pointing of the vaginal canal, are consequences of eternal youth. But upright posture is a different phenomenon. It cannot be achieved by the “easy” route of retaining a feature already present in juvenile stages. For a baby’s legs are relatively small and weak, while bipedal posture demands enlargement and strengthening of the legs.

By the time we became upright as *A. afarensis*, the game was largely over, the major alteration of architecture accom-

plished, the trigger of future change already set. The later enlargement of our brain was anatomically easy. We read our larger brain out of the program of our own growth, by prolonging rapid rates of fetal growth to later times and preserving, as adults, the characteristic proportions of a juvenile primate skull. And we evolved this brain in concert with a host of other neotenic features, all part of a general pattern.

Yet I must end by pulling back and avoiding a fallacy of reasoning—the false equation between magnitude of effect and intensity of cause. As a pure problem in architectural reconstruction, upright posture is far-reaching and fundamental, an enlarged brain superficial and secondary. But the effect of our large brain has far outstripped the relative ease of its construction. Perhaps the most amazing thing of all is a general property of complex systems, our brain prominent among them—their capacity to translate merely quantitative changes in structure into wondrously different qualities of function.

It is now two in the morning and I'm finished. I think I'll walk over to the refrigerator and get a beer; then I'll go to sleep. Culture-bound creature that I am, the dream I will have in an hour or so when I'm supine astounds me ever so much more than the stroll I will now perform perpendicular to the floor.