



1.2. A modern reconstruction of the Burgess Shale fauna, illustrating an article by Briggs and Whittington on the genus *Anomalocaris*. This drawing, unlike Knight's, features odd organisms. *Sidneyia* has been banished to the lower right, and the scene is dominated by two specimens of the giant *Anomalocaris*. Three *Aysheaia* feed on sponges along the lower border, left of *Sidneyia*. An *Opabinia* crawls along the bottom just left of *Aysheaia*. Two *Wiwaxia* graze on the sea floor below the upper *Anomalocaris*.

### THE LADDER AND THE CONE: ICONOGRAPHIES OF PROGRESS

Familiarity has been breeding overtime in our mottoes, producing everything from contempt (according to Aesop) to children (as Mark Twain observed). Polonius, amidst his loquacious wanderings, urged Laertes to seek friends who were tried and true, and then, having chosen well, to "grapple them" to his "soul with hoops of steel."

Yet, as Polonius's eventual murderer stated in the most famous soliloquy of all time, "there's the rub." Those hoops of steel are not easily unbound, and the comfortably familiar becomes a prison of thought.

Words are our favored means of enforcing consensus; nothing inspires orthodoxy and purposeful unanimity of action so well as a finely crafted motto—Win one for the Gipper, and God shed his grace on thee. But our

recent invention of speech cannot entirely bury an earlier heritage. Primates are visual animals par excellence, and the iconography of persuasion strikes even closer than words to the core of our being. Every demagogue, every humorist, every advertising executive, has known and exploited the evocative power of a well-chosen picture.

Scientists lost this insight somewhere along the way. To be sure, we use pictures more than most scholars, art historians excepted. *Next slide please* surpasses even *It seems to me that* as the most common phrase in professional talks at scientific meetings. But we view our pictures only as ancillary illustrations of what we defend by words. Few scientists would view an image itself as intrinsically ideological in content. Pictures, as accurate mirrors of nature, just are.

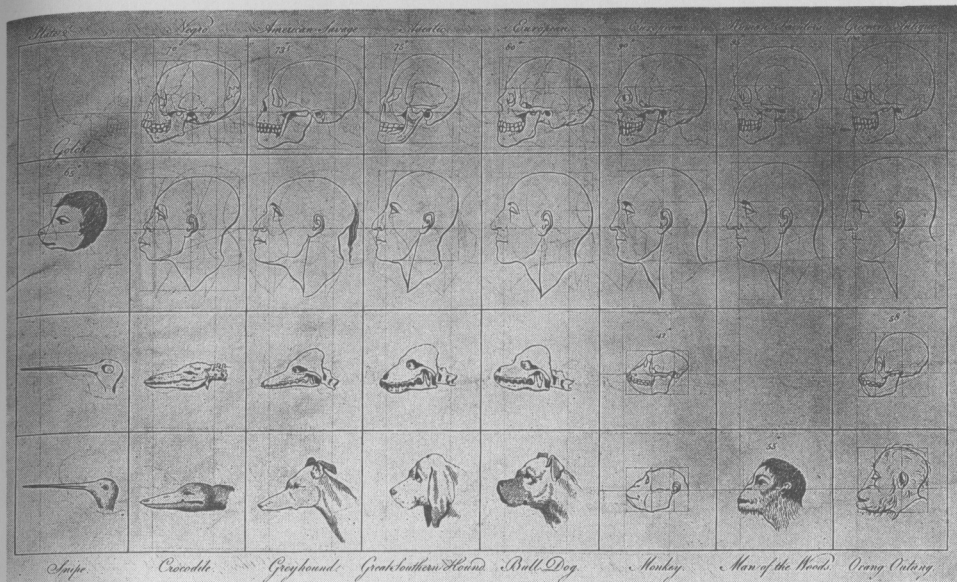
I can understand such an attitude directed toward photographs of objects—though opportunities for subtle manipulation are legion even here. But many of our pictures are incarnations of concepts masquerading as neutral descriptions of nature. These are the most potent sources of conformity, since ideas passing as descriptions lead us to equate the tentative with the unambiguously factual. Suggestions for the organization of thought are transformed to established patterns in nature. Guesses and hunches become things.

The familiar iconographies of evolution are all directed—sometimes crudely, sometimes subtly—toward reinforcing a comfortable view of human inevitability and superiority. The starkest version, the chain of being or ladder of linear progress, has an ancient, pre-evolutionary pedigree (see A. O. Lovejoy's classic, *The Great Chain of Being*, 1936). Consider, for example, Alexander Pope's *Essay on Man*, written early in the eighteenth century:

Far as creation's ample range extends,  
The scale of sensual, mental powers ascends:  
Mark how it mounts, to man's imperial race,  
From the green myriads in the peopled grass.

And note a famous version from the very end of that century (figure 1.3). In his *Regular Gradation in Man*, British physician Charles White shoe-horned all the ramifying diversity of vertebrate life into a single motley sequence running from birds through crocodiles and dogs, past apes, and up the conventional racist ladder of human groups to a Caucasian paragon, described with the rococo flourish of White's dying century:

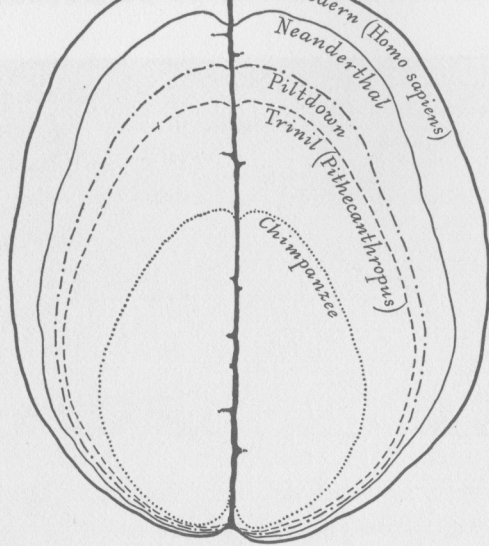
Where shall we find, unless in the European, that nobly arched head, con-



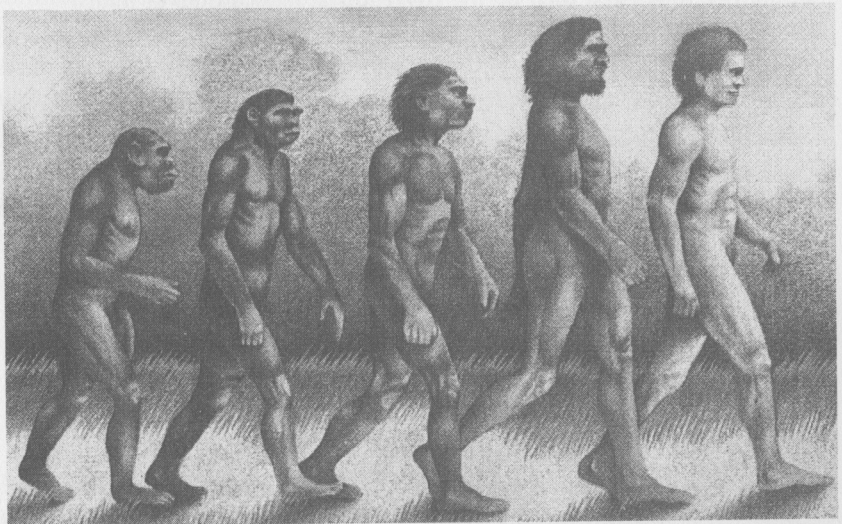
1.3. The linear gradations of the chain of being according to Charles White (1799). A motley sequence runs from birds to crocodiles to dogs and monkeys (bottom two rows), and then up the conventional racist ladder of human groups (top two rows).

taining such a quantity of brain . . . ? Where the perpendicular face, the prominent nose, and round projecting chin? Where that variety of features, and fullness of expression, . . . those rosy cheeks and coral lips? (White, 1799).

This tradition never vanished, even in our more enlightened age. In 1915, Henry Fairfield Osborn celebrated the linear accretion of cognition in a figure full of illuminating errors (figure 1.4). Chimps are not ancestors but modern cousins, equally distant in evolutionary terms from the unknown forebear of African great apes and humans. *Pithecanthropus* (*Homo erectus* in modern terms) is a potential ancestor, and the only legitimate member of the sequence. The inclusion of Piltdown is especially revealing. We now know that Piltdown was a fraud composed of a modern human cranium and an ape's jaw. As a contemporary cranium, Piltdown possessed a brain of modern size; yet so convinced were Osborn's colleagues that human fossils must show intermediate values on a ladder of progress, that they reconstructed Piltdown's brain according to their expectations. As for Neanderthal, these creatures were probably close cousins



1.4. Progress in the evolution of the human brain as illustrated by Henry Fairfield Osborn in 1915.

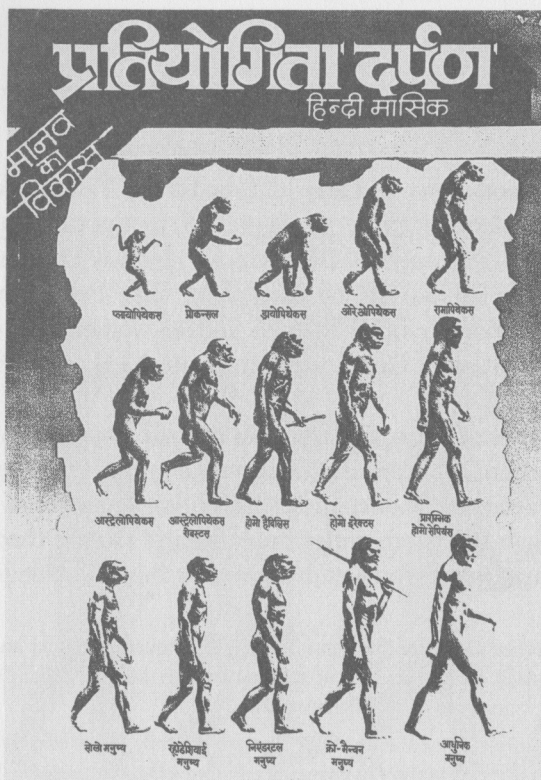


1.5. A personally embarrassing illustration of our allegiance to the iconography of the march of progress. My books are dedicated to debunking this picture of evolution, but I have no control over jacket designs for foreign translations. Four translations of my books have used the “march of human progress” as a jacket illustration. This is from the Dutch translation of *Ever Since Darwin*.

belonging to a separate species, not ancestors. In any case, they had brains as large as ours, or larger, Osborn's ladder notwithstanding.

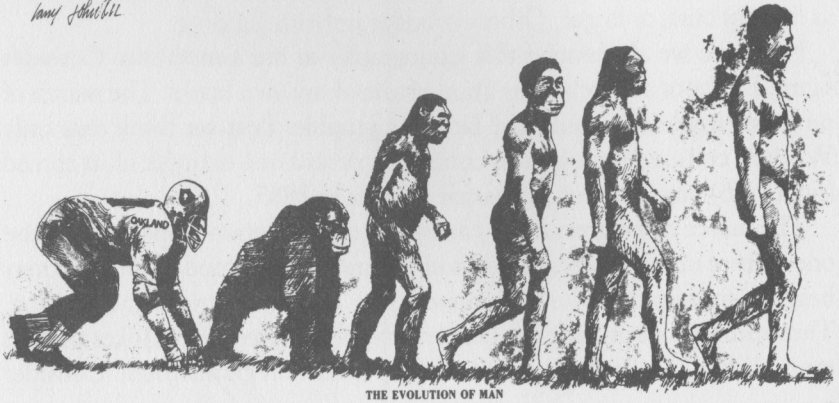
Nor have we abandoned this iconography in our generation. Consider figure 1.5, from a Dutch translation of one of my own books! The march of progress, single file, could not be more graphic. Lest we think that only Western culture promotes this conceit, I present one example of its spread (figure 1.6) purchased at the bazaar of Agra in 1985.

The march of progress is *the* canonical representation of evolution—the one picture immediately grasped and viscerally understood by all. This may best be appreciated by its prominent use in humor and in advertising. These professions provide our best test of public perceptions. Jokes and ads must click in the fleeting second that our attention grants them. Consider



1.6. I bought this children's science magazine in the bazaar of Agra, in India. The false iconography of the march of progress now has cross-cultural acceptance.

Larry Johnson



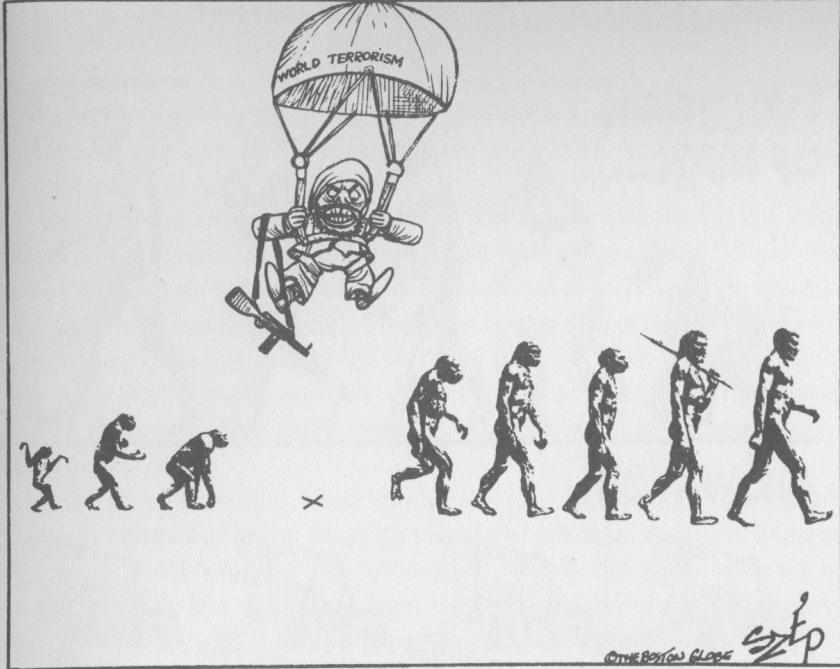
1.7. A cartoonist can put the iconography of the ladder to good use. This example by Larry Johnson appeared in the *Boston Globe* before a Patriots–Raiders game.

figure 1.7, a cartoon drawn by Larry Johnson for the *Boston Globe* before a Patriots–Raiders football game. Or figure 1.8, by the cartoonist Szep, on the proper place of terrorism. Or figure 1.9, by Bill Day, on “scientific creationism.” Or figure 1.10, by my friend Mike Peters, on the social possibilities traditionally open to men and to women. For advertising, consider the evolution of Guinness stout (figure 1.11) and of rental television (figure 1.12).\*

The straitjacket of linear advance goes beyond iconography to the definition of evolution: the word itself becomes a synonym for *progress*. The makers of Doral cigarettes once presented a linear sequence of “improved” products through the years, under the heading “Doral’s theory of evolution.”† (Perhaps they are now embarrassed by this misguided claim, since

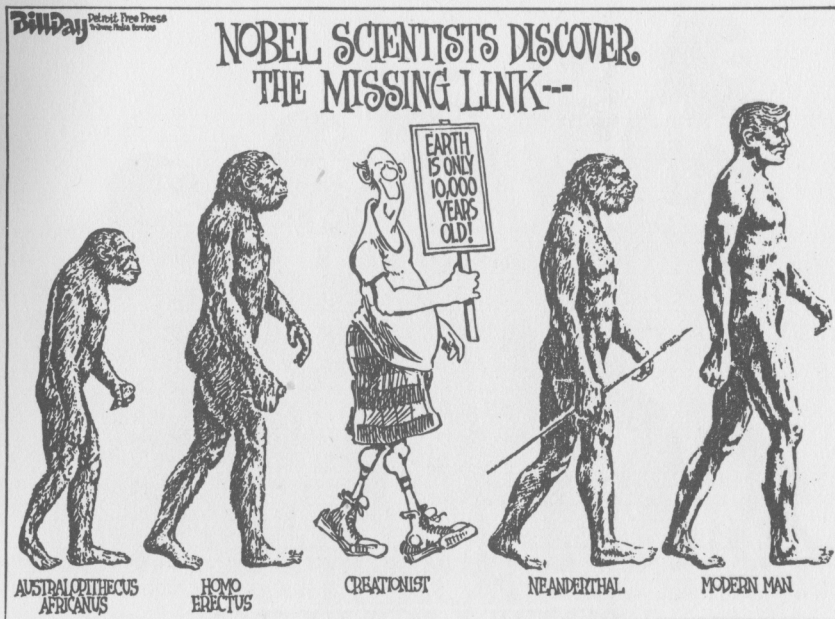
\*Invoking another aspect of the same image—the equation of old and extinct with inadequate—Granada exhorts us to rent rather than buy because “today’s latest models could be obsolete before you can say brontosaurus.”

†Wonderfully ironic, since the sequence showed, basically, more effective filters. Evolution, to professionals, is adaptation to changing environments, not progress. Since the filters were responses to new conditions—public knowledge of health dangers—Doral did use the term *evolution* properly. Surely, however, they intended “absolutely better” rather than “punting to maintain profit”—a rather grisly claim in the light of several million deaths attributable to cigarette smoking.



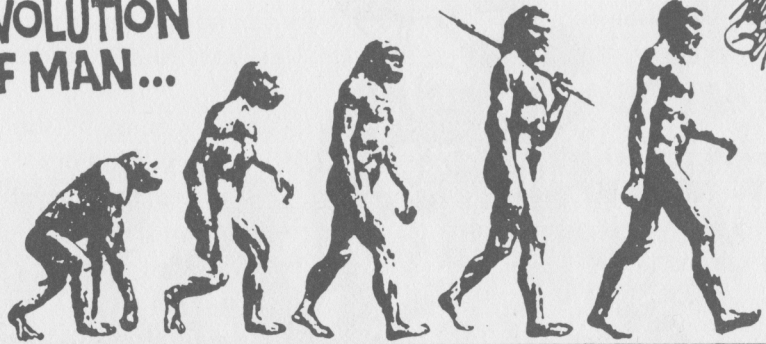
*A place in history*

1.8. World terrorism parachutes into its appropriate place in the march of progress. By Szep, in the *Boston Globe*.



1.9. A “scientific creationist” takes his appropriate place in the march of progress. By Bill Day, in the *Detroit Free Press*.

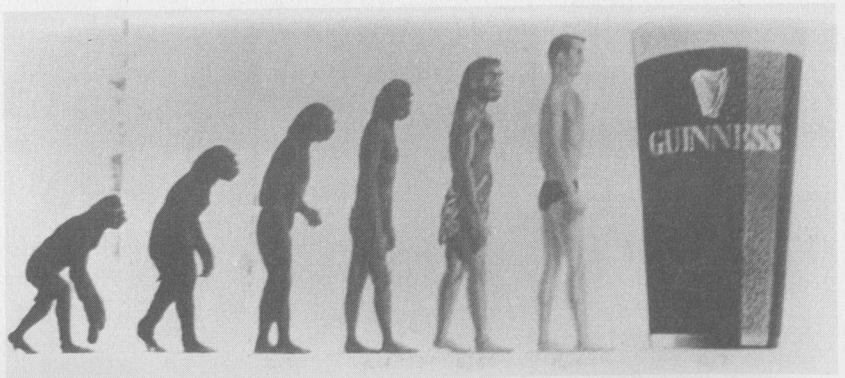
# EVOLUTION OF MAN...



and woman.



1.10. More mileage from the iconography of the ladder. By Mike Peters, in the *Dayton Daily News*. (Reprinted by permission of UFS, Inc.)

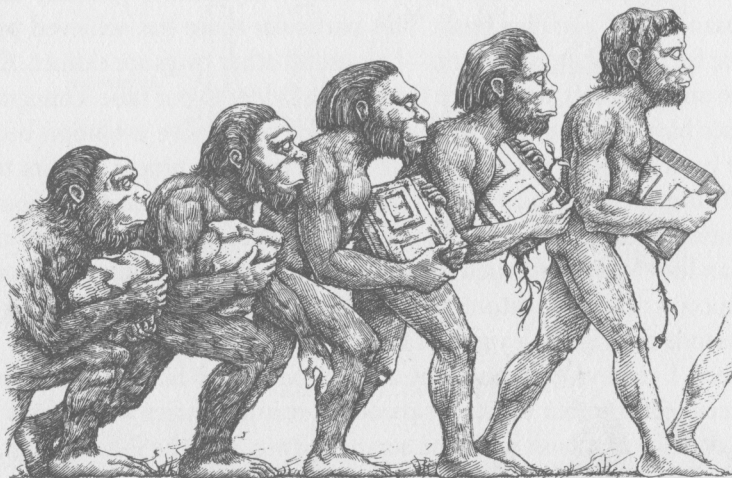


1.11. The highest stage of human advance as photographed from an English billboard.

they refused me permission to reprint the ad.) Or consider an episode from the comic strip *Andy Capp* (figure 1.13). Flo has no problem in accepting evolution, but she defines it as progress, and views Andy's quadrupedal homecoming as quite the reverse.

Life is a copiously branching bush, continually pruned by the grim reaper of extinction, not a ladder of predictable progress. Most people may know this as a phrase to be uttered, but not as a concept brought into the deep interior of understanding. Hence we continually make errors inspired by unconscious allegiance to the ladder of progress, even when we explicitly deny such a superannuated view of life. For example, consider two errors, the second providing a key to our conventional misunderstanding of the Burgess Shale.

First, in an error that I call "life's little joke" (Gould, 1987a), we are virtually compelled to the stunning mistake of citing unsuccessful lineages as classic "textbook cases" of "evolution." We do this because we try to extract a single line of advance from the true topology of copious branching. In this misguided effort, we are inevitably drawn to bushes so near the brink of total annihilation that they retain only one surviving twig. We then view this twig as the acme of upward achievement, rather than the probable last gasp of a richer ancestry.



## GRANADA TV RENTAL'S THEORY OF EVOLUTION.

1.12. The march of progress as portrayed in another advertisement.

ANDY CAPP

By Reg Smythe



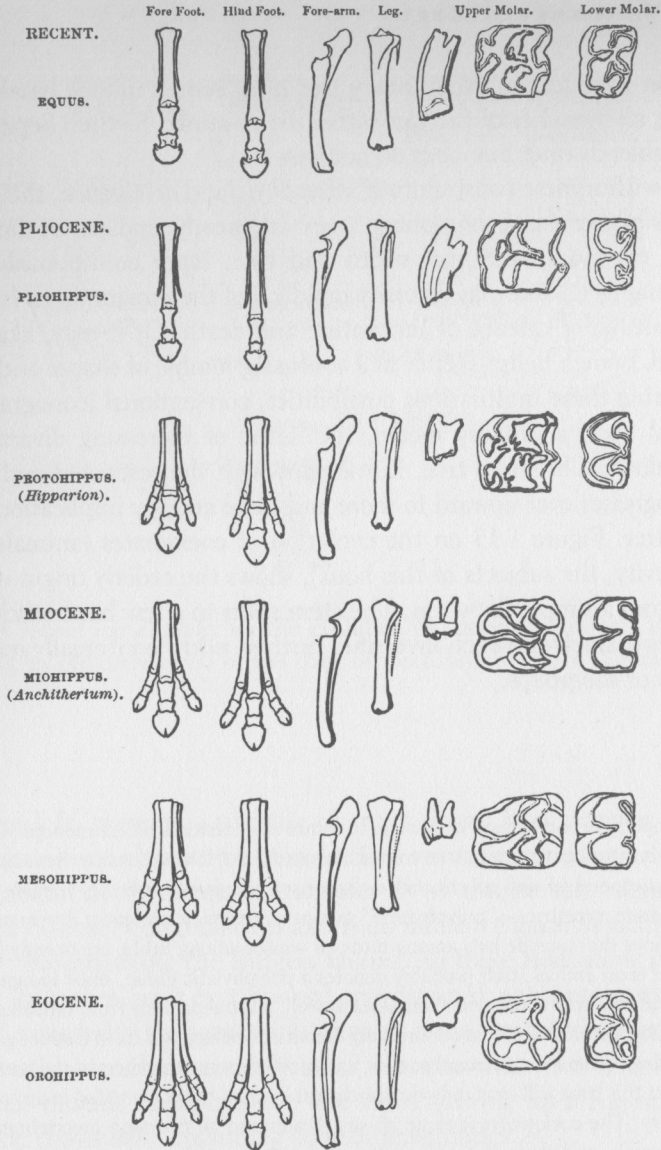
1.13. The vernacular equation of evolution with progress. Andy's quadrupedal posture is interpreted as evolution in reverse. (By permission of © M.G.N. 1989, Syndication International/North America Syndicate, Inc.)

Consider the great warhorse of tradition—the evolutionary ladder of horses themselves (figure 1.14). To be sure, an unbroken evolutionary connection does link *Hyracotherium* (formerly called *Eohippus*) to modern *Equus*. And, yes again, modern horses are bigger, with fewer toes and higher crowned teeth. But *Hyracotherium*–*Equus* is not a ladder, or even a central lineage. This sequence is but one labyrinthine pathway among thousands on a complex bush. This particular route has achieved prominence for just one ironic reason—because all other twigs are extinct. *Equus* is the only twig left, and hence the tip of a ladder in our false iconography. Horses have become the classic example of progressive evolution because their bush has been so unsuccessful. We never grant proper acclaim to the real triumphs of mammalian evolution. Who ever hears a story about the evolution of bats, antelopes, or rodents—the current champions of mammalian life? We tell no such tales because we cannot linearize the bounteous success of these creatures into our favored ladder. They present us with thousands of twigs on a vigorous bush.

Need I remind everyone that at least one other lineage of mammals, especially dear to our hearts for parochial reasons, shares with horses both the topology of a bush with one surviving twig, and the false iconography of a march to progress?

In a second great error, we may abandon the ladder and acknowledge the branching character of evolutionary lineages, yet still portray the tree of life in a conventional manner chosen to validate our hopes for predictable progress.

The tree of life grows with a few crucial constraints upon its form. First, since any well-defined taxonomic group can trace its origin to a single



GENEALOGY OF THE HORSE.

1.14. The original version of the ladder of progress for horses, drawn by the American paleontologist O. C. Marsh for Thomas Henry Huxley after Marsh had shown his recently collected Western fossils to Huxley on his only visit to the United States. Marsh convinced his English visitor about this sequence, thus compelling Huxley to revamp his lecture on the evolution of horses given in New York in 1876. Note the steady decrease in number of toes and increase in height of teeth. Since Marsh drew all his specimens the same size, we do not see the other classical trend of increase in stature.

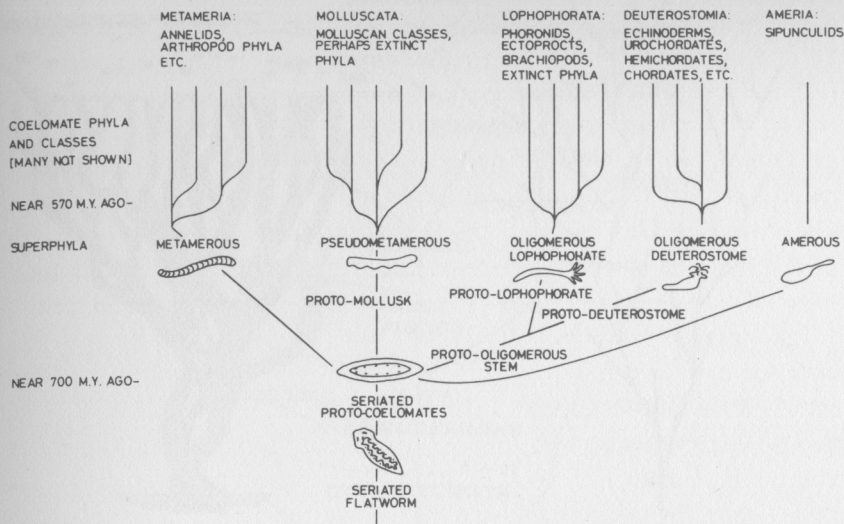
common ancestor, an evolutionary tree must have a unique basal trunk.\* Second, all branches of the tree either die or ramify further. Separation is irrevocable; distinct branches do not join.†

Yet, within these constraints of *monophyly* and *divergence*, the geometric possibilities for evolutionary trees are nearly endless. A bush may quickly expand to maximal width and then taper continuously, like a Christmas tree. Or it may diversify rapidly, but then maintain its full width by a continuing balance of innovation and death. Or it may, like a tumbleweed, branch helter-skelter in a confusing jumble of shapes and sizes.

Ignoring these multifarious possibilities, conventional iconography has fastened upon a primary model, the “cone of increasing diversity,” an upside-down Christmas tree. Life begins with the restricted and simple, and progresses ever upward to more and more and, by implication, better and better. Figure 1.15 on the evolution of coelomates (animals with a body cavity, the subjects of this book), shows the orderly origin of everything from a simple flatworm. The stem splits to a few basic stocks; none becomes extinct; and each diversifies further, into a continually increasing number of subgroups.

\*A properly defined group with a single common ancestor is called monophyletic. Taxonomists insist upon monophyly in formal classification. However, many vernacular names do not correspond to well-constituted evolutionary groups because they include creatures with disparate ancestries—“polyphyletic” groups in technical parlance. For example, folk classifications that include bats among birds, or whales among fishes, are polyphyletic. The vernacular term *animal* itself probably denotes a polyphyletic group, since sponges (almost surely), and probably corals and their allies as well, arose separately from unicellular ancestors—while all other animals of our ordinary definitions belong to a third distinct group. The Burgess Shale contains numerous sponges, and probably some members of the coral phylum as well, but this book will treat only the third great group—the coelomates, or animals with a body cavity. The coelomates include all vertebrates and all common invertebrates except sponges, corals, and their allies. Since the coelomates are clearly monophyletic (Hanson, 1977), the subjects of this book form a proper evolutionary group.

†This fundamental principle, while true for the complex multicellular animals treated in this book, does not apply to all life. Hybridization between distant lineages occurs frequently in plants, producing a “tree of life” that often looks more like a network than a conventional bush. (I find it amusing that the classic metaphor of the tree of life, used as a picture of evolution ever since Darwin and so beautifully accurate for animals, may not apply well to plants, the source of the image.) In addition, we now know that genes can be transferred laterally, usually by viruses, across species boundaries. This process may be important in the evolution of some unicellular creatures, but probably plays only a small role in the phylogeny of complex animals, if only because two embryological systems based upon intricately different developmental pathways cannot mesh, films about flies and humans notwithstanding.

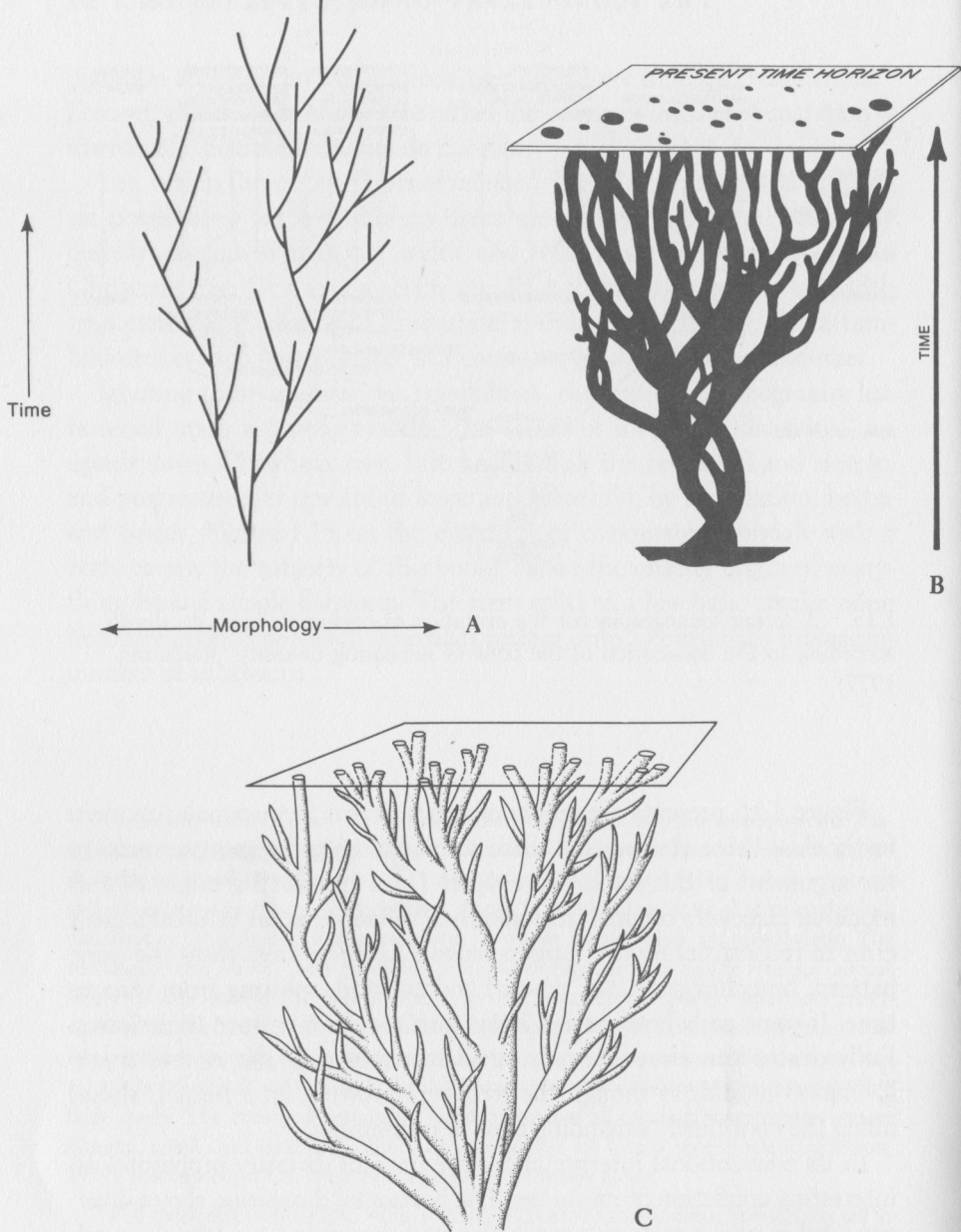


1.15. A recent iconography for the evolution of coelomate animals, drawn according to the convention of the cone of increasing diversity (Valentine, 1977).

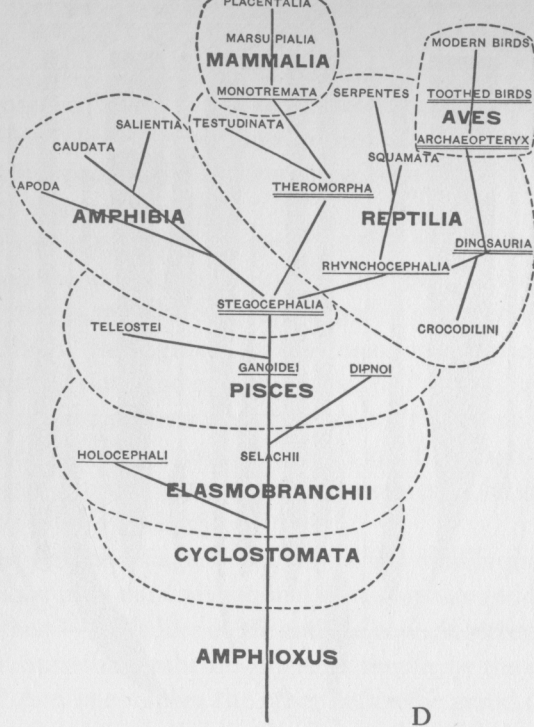
Figure 1.16 presents a panoply of cones drawn from popular modern textbooks—three abstract and three actual examples for groups crucial to the argument of this book. (In chapter IV, I discuss the origin of this model in Haeckel's original trees and their influence upon Walcott's great error in reconstructing the Burgess fauna.) All these trees show the same pattern: branches grow ever upward and outward, splitting from time to time. If some early lineages die, later gains soon overbalance these losses. Early deaths can eliminate only small branches near the central trunk. Evolution unfolds as though the tree were growing up a funnel, always filling the continually expanding cone of possibilities..

In its conventional interpretation, the cone of diversity propagates an interesting conflation of meanings. The horizontal dimension shows diversity—fishes plus insects plus snails plus starfishes at the top take up much more lateral room than just flatworms at the bottom. But what does the vertical dimension represent? In a literal reading, up and down should record only younger and older in geological time: organisms at the neck of the funnel are ancient; those at the lip, recent. But we also read upward movement as simple to complex, or primitive to advanced. *Placement in time is conflated with judgment of worth.*

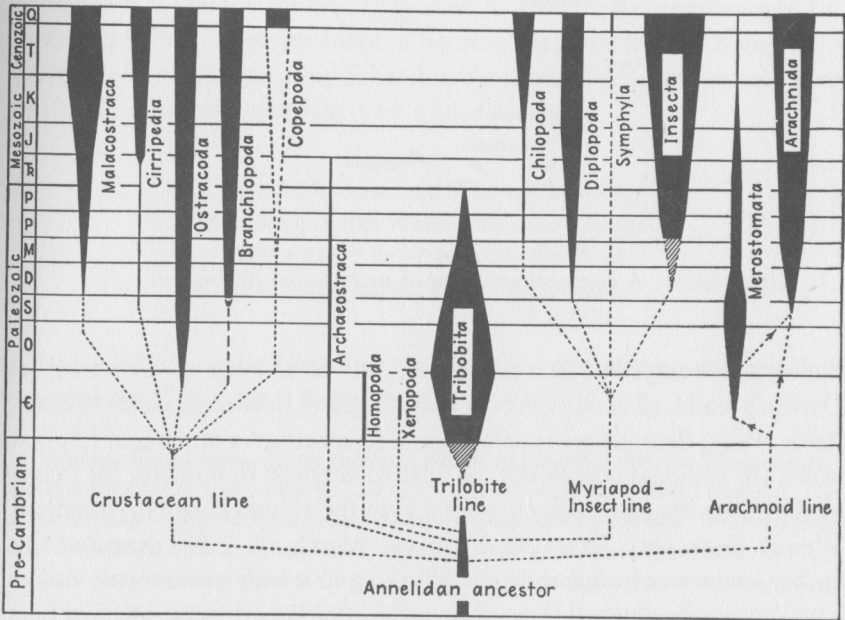
Our ordinary discourse about animals follows this iconography. Nature's



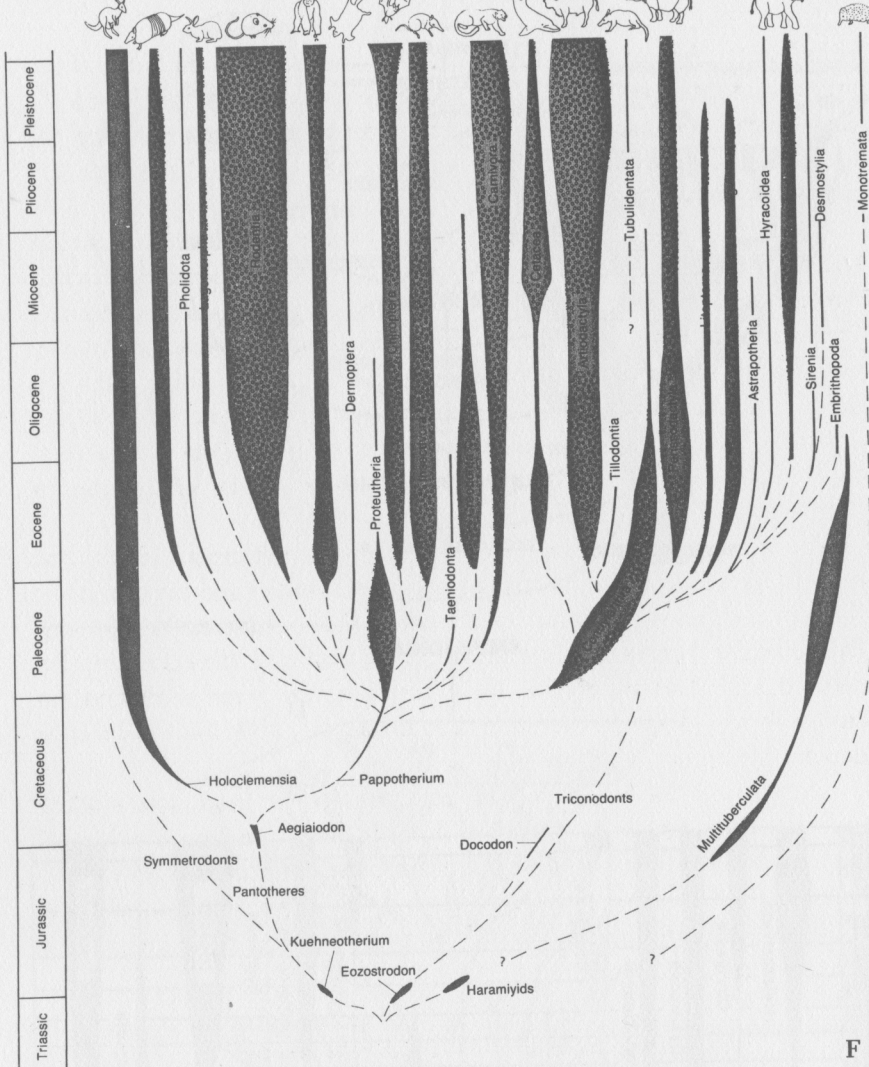
1.16. The iconography of the cone of increasing diversity, as seen in six examples from textbooks. All these diagrams are presented as simple objective portrayals of evolution; none are explicit representations of diversification as opposed to some other evolutionary process. Three abstract examples (A–C) are followed by conventional views of three specific phylogenies—vertebrate (D), arthropod (E), and mammalian (F, on p. 42). The data of the Burgess Shale falsify this central view of arthropod evolution as a continuous process of increasing diversification.



D



E



1.16 (continued). A conventional view of mammalian phylogeny.

there is diversity. We live surrounded by coeval twigs of life's tree. In Darwin's world, all (as survivors in a tough game) have some claim to equal status. Why, then, do we usually choose to construct a ranking of implied worth (by assumed complexity, or relative nearness to humans, for example)? In a review of a book on courtship in the animal kingdom, Jonathan Weiner (*New York Times Book Review*, March 27, 1988) describes the author's scheme of organization: "Working in loosely evolutionary order, Mr. Walters begins with horseshoe crabs, which have been meeting and mating on dark beaches in synchrony with tide and moon for 200 million

years.” Later chapters make the “long evolutionary leap to the antics of the pygmy chimpanzee.” Why is this sequence called “evolutionary order”? Anatomically complex horseshoe crabs are not ancestral to vertebrates; the two phyla, Arthropoda and Chordata, have been separate from the very first records of multicellular life.

In another recent example, showing that this error infests technical as well as lay discourse, an editorial in *Science*, the leading scientific journal in America, constructs an order every bit as motley and senseless as White’s “regular gradation” (see figure 1.3). Commenting on species commonly used for laboratory work, the editors discuss the “middle range” between unicellular creatures and guess who at the apex: “Higher on the evolutionary ladder,” we learn, “the nematode, the fly and the frog have the advantage of complexity beyond the single cell, but represent far simpler species than mammals” (June 10, 1988).

The fatuous idea of a single order amidst the multifarious diversity of modern life flows from our conventional iconographies and the prejudices that nurture them—the ladder of life and the cone of increasing diversity. By the ladder, horseshoe crabs are judged as simple; by the cone, they are deemed old.\* And one implies the other under the grand conflation discussed above—down on the ladder also means old, while low on the cone denotes simple.

I don’t think that any particular secret, mystery, or inordinate subtlety underlies the reasons for our allegiance to these false iconographies of ladder and cone. They are adopted because they nurture our hopes for a universe of intrinsic meaning defined in our terms. We simply cannot bear the implications of Omar Khayyám’s honesty:

Into this Universe, and Why not knowing,  
Nor whence, like Water willy-nilly flowing:  
And out of it, as Wind along the Waste  
I know not Whither, willy-nilly blowing.

A later quatrain of the *Rubáiyát* proposes a counteracting strategy, but acknowledges its status as a vain hope:

\*Another factual irony: despite the usual picture of horseshoe crabs as “living fossils,” *Limulus polyphemus* (our American East Coast species) has no fossil record whatever. The genus *Limulus* ranges back only some 20 million years, not 200 million. We mistakenly regard horseshoe crabs as “living fossils” because the group has never produced many species, and therefore never developed much evolutionary potential for diversification; consequently, modern species are morphologically similar to early forms. But the species themselves are not notably old.

Ah Love! could you and I with Fate conspire  
To grasp this sorry Scheme of Things entire,  
Would we not shatter it to bits—and then  
Re-mold it nearer to the Heart's Desire!

Most myths and early scientific explanations of Western culture pay homage to this "heart's desire." Consider the primal tale of Genesis, presenting a world but a few thousand years old, inhabited by humans for all but the first five days, and populated by creatures made for our benefit and subordinate to our needs. Such a geological background could inspire Alexander Pope's confidence, in the *Essay on Man*, about the deeper meaning of immediate appearances:

All Nature is but art, unknown to thee;  
All chance, direction, which thou canst not see;  
All discord, harmony not understood;  
All partial evil, universal good.

But, as Freud observed, our relationship with science must be paradoxical because we are forced to pay an almost intolerable price for each major gain in knowledge and power—the psychological cost of progressive dethronement from the center of things, and increasing marginality in an uncaring universe. Thus, physics and astronomy relegated our world to a corner of the cosmos, and biology shifted our status from a simulacrum of God to a naked, upright ape.

To this cosmic redefinition, my profession contributed its own special shock—geology's most frightening fact, we might say. By the turn of the last century, we knew that the earth had endured for millions of years, and that human existence occupied but the last geological millimicrosecond of this history—the last inch of the cosmic mile, or the last second of the geological year, in our standard pedagogical metaphors.

We cannot bear the central implication of this brave new world. If humanity arose just yesterday as a small twig on one branch of a flourishing tree, then life may not, in any genuine sense, exist for us or because of us. Perhaps we are only an afterthought, a kind of cosmic accident, just one bauble on the Christmas tree of evolution.

What options are left in the face of geology's most frightening fact? Only two, really. We may, as this book advocates, accept the implications and learn to seek the meaning of human life, including the source of morality, in other, more appropriate, domains—either stoically with a sense of loss, or with joy in the challenge if our temperament be optimistic. Or we may continue to seek cosmic comfort in nature by reading life's history in a distorted light.

If we elect the second strategy, our maneuvers are severely restricted by our geological history. When we infested all but the first five days of time, the history of life could easily be rendered in our terms. But if we wish to assert human centrality in a world that functioned without us until the last moment, we must somehow grasp all that came before as a grand preparation, a foreshadowing of our eventual origin.

The old chain of being would provide the greatest comfort, but we now know that the vast majority of "simpler" creatures are not human ancestors or even prototypes, but only collateral branches on life's tree. The cone of increasing progress and diversity therefore becomes our iconography of choice. The cone implies predictable development from simple to complex, from less to more. *Homo sapiens* may form only a twig, but if life moves, even fitfully, toward greater complexity and higher mental powers, then the eventual origin of self-conscious intelligence may be implicit in all that came before. In short, I cannot understand our continued allegiance to the manifestly false iconographies of ladder and cone except as a desperate finger in the dike of cosmically justified hope and arrogance.

I leave the last word on this subject to Mark Twain, who grasped so graphically, when the Eiffel Tower was the world's tallest building, the implications of geology's most frightening fact:

Man has been here 32,000 years. That it took a hundred million years to prepare the world for him\* is proof that that is what it was done for. I suppose it is. I dunno. If the Eiffel Tower were now representing the world's age, the skin of paint on the pinnacle knob at its summit would represent man's share of that age; and anybody would perceive that the skin was what the tower was built for. I reckon they would, I dunno.

## REPLAYING LIFE'S TAPE: THE CRUCIAL EXPERIMENT

The iconography of the cone made Walcott's original interpretation of the Burgess fauna inevitable. Animals so close in time to the origin

\*Twain used Lord Kelvin's estimate, then current, for the age of the earth. The estimated ages have lengthened substantially since then, but Twain's proportions are just about right. He took human existence as about 1/30,000 of the earth's age. At current estimates of 250,000 years for the origin of our species, *Homo sapiens*, the earth would be 7.5 billion years old if our span were 1/30,000 of totality. By best current estimates, the earth is 4.5 billion years old.