The Structure Of Evolutionary Theory
times, and surely cannot be marked as doomed, or even in decline with respect to mammals, during such a period of maintenance and expansion by copious speciation, or introduction of new Darwinian species-individuals at this macroevolutionary level. And then, with catastrophism reintroduced at the third tier as a hypothesis of renewed respectability, the ceratopsians died, in concert with all other dinosaurs (leaving the anatomically divergent birds as sole survivors of their monophyletic clade), when an unpredictable paroxysmal change radically altered earthly environments and drove several groups to extinction through no adaptive failure of their own, while imparting fortuitous exaptive success to creatures that had lived throughout the long reign of dinosaurs, and never made any headway towards displacement, or even towards shared domination with one of the most successful vertebrate groups in the history of life.

An Epilog on Theory and History in Creating the Grandeur of This View of Life

This comfortable view of ceratopsian (and all dinosaurian) demise engendered smug feelings among evolutionists and paleontologists of previous generations for two reasons, both lamentable. First, the implied pattern of a lawlike and predictable vector of progress, culminating in mammalian victory over dinosaurs and crowned by the eventual evolution of a single conscious scribe within the triumphant clade, validated the oldest social traditions and deepest psychological hopes of Western cultures—the strongest possible reason for turning our brightest beacon of skepticism upon so congenial a conclusion defended by so little beyond emotional satisfaction. Second, the supposed underpinning (and virtual guarantee) of this happy result by a putative general law of nature, enhanced the meaning and centrality of the particular outcome as a dictate of universal science, not merely a fortuitous circumstance, or even a special dictate of an arcane controlling power whose comprehensive reasons can never be entirely known (and whose future actions can therefore never be fully anticipated).

If, however, as the central thesis of this book maintains and the Zeitgeist of our dawning millennium no longer rejects, we cannot validate the actuality of mammalian success by general principles, but only as a happy (albeit entirely sensible) contingency of a historical process with innumerable alternatives that didn’t happen to attain expression (despite their equal plausibility before the fact), then we must face the philosophical question of whether we have surrendered too much in developing a more complex and nuanced view of causality in the history of life.

What is science, after all, if not the attempt to understand the natural world by explaining its phenomenology as causal consequences of spatiotemporally invariant laws? We may need to know the particularities of a given set of initial conditions in order to infer the details of later states reached by the operation of these laws, but we do not regard the resolution of such details as essential or causal components of the explanation itself. (I confess that, after 30 years of teaching at a major university, I remain surprised by the unquestioned acceptance of this view of science—which, by the way, I strongly reject for reasons exemplified just below—among students headed for a life in this profession, and among intellectually inclined people in general. If, as a teacher, I suggest to students that they might wish to construe probability and contingency as ontological properties of nature, they often become confused, or even angry, and almost invariably respond with some version of the old Laplacean claim. In short, they insist that our use of probabilistic inference can only, and in principle, be an epistemological consequence of our mental limitations, and simply cannot represent an irreducible property of nature, which must, if science works at all, be truly deterministic.)

Natural historians have too often been apologetic—but most emphatically should not be—in supporting a plurality of legitimately scientific modes, including a narrative or historical style that explicitly links the explanation of outcomes not only to spatiotemporally invariant laws of nature, but also, if not primarily, to the specific contingencies of antecedent states, which, if constituted differently, could not have generated the observed result. As these antecedent states are, themselves, particulars of history rather than necessary expressions of law, and as subsequent configurations can cascade in innumerable directions, each crucially dependent upon tiny differences in the antecedent states, we regard these subsequent outcomes as unpredictable in principle (as an ontological property of nature’s probabilistic constitution, not as a limitation of our minds, or as a sign of the inferior status of historical science), however fully explainable they will become, at least in principle, after their occurrence as the single actualized result among innumerable unrealized possibilities.

In order to gain entry into the hallowed halls of science (often defined, far too parochially, in terms of quantified predictability as a summum bonum), natural historians have often been too willing to accept an inferior status, based on the principled unpredictability of their largely contingent phenomenology, in order to gain recognition as practitioners of science at all. (For in this Laplacean construction, the frequency of probabilistic inference correlates directly with the weakness of scientific apparatus—for we live, under this fallacy, in a genuinely deterministic world, and the extent of our recourse to probability therefore maps our relative inability to define the true determinisms of any particular process.)

Wise natural historians, with Darwin himself as a most articulate champion, have always rejected this disparagement, and its attendant relegation to inferior status—and have defended historical explanation, with its claims for contingency and the ontological status of probabilistic structure, as a fascinating, even inspirational, property of complex nature. Such contingency, moreover, in no way compromises the power of legitimate explanation, for our inability to predict before the fact only records the true character of this complexity, whereas our subsequent capacity to explain after the fact can
reach the same level of confidence as any physical resolution under invariant law, provided that we can obtain enough factual detail about antecedent states to resolve their causal relation to the observed outcome. In fact, and on this very subject, Darwin made a striking exception to his astonishingly calm and genial temperament, and permitted himself a rare excursion into satire and sharp criticism. Moreover, he expressed these partisan thoughts in the most prominent of all possible places—the very last line of the Origin of Species, where he rejected the traditional claims of quantitative physical science to represent the apotheosis of sophistication, and awarded higher honor to his own discipline of natural history and evolutionary biology, as embodied in the gnarly and meandering icon of the luxuriantly, but contingently, branching tree of life.

But Darwin, ever so sly in his Victorian propriety, enshrined this terminal line in such a flourish of benign prose that most readers, for more than a century, have construed his famous closing sentence as a poetic metaphor, intended only to ornament a revolution with a coda of ecumenical kindness. In fact, I am convinced that Darwin conceived this finale primarily as a mordant critique of the haughtiness and narrowness of physical scientists in debasing natural history, and as a defense of the greater interest and relevance of his own chosen profession. (I need only recall Darwin's extreme discomfort at Lord Kelvin's arrogant dismissal both of natural selection in particular, and Lyellian geology in general—see Chapter 6 for details. This famous incident should remind readers that Darwin may well have harbored angry feelings about the pretensions of mathematical physics and celestial mechanics to superior status over natural history among the sciences.)

Note how Darwin contrasts the dull repetitiveness of planetary cycling (despite the elegance and simplicity of its quantitative expression) with the gutsy glory of rich diversity on life's ever rising and expanding tree. Darwin even gives his metaphor a geometric flavor, as he contrasts the horizontal solar system, its planets cycling around a central sun to nowhere, with the vertical tree of life, starting in utmost simplicity at the bottom, and rising right through the horizontality of this repetitive physical setting towards the heavenly heights of magnificent and ever expanding diversity, into a contingent and unpredictable future of still greater possibility: "There is grandeur in this view of life . . . [and] whilst this planet has gone cycling on according to the fixed law of gravity, from so simple a beginning endless forms most beautiful and most wonderful have been, and are being, evolved" (1859, p. 490).

Throughout the Origin of Species, Darwin stresses the beauty, and especially the simplifying power, of historical explanation in evolutionary science as a cardinal feature of his view of life (as opposed to other versions of evolution). In one of the most striking examples of "less is more" in the history of science (eloquently and elegantly more in this case), Darwin continually emphasizes that the age-old perception of a "natural system" among organisms had always presumed a basis of order that must be complex, arcane and abstract; intricately numerical and geometrically lawlike; or divinely ordained, and therefore of literally highest and deepest significance. Louis Agassiz, Darwin's near contemporary and the last truly sophisticated scientific creationist in biological theory, had even argued (see Chapter 3 for an exegesis of his view) that since each species represents a single divine idea incarnated on earth, the "natural system" of taxonomic order among species must literally record the character of God's mind, for taxonomy discovers the principles of higher structuring among God's own unitary items of thought.

But Darwin's profound, and wonderfully simple, alternative cuts through centuries of assumptions about the unresolvable depth and complexity of natural order with a breathtakingly direct and concrete resolution: the "natural system," or taxonomic order among species, just records the history of an unbroken genealogical sequence of historical descent, the arboreal topology of the tree of life. The height of arcane mystery becomes a record of simple history: "As all the organic beings, extinct and recent, which have ever lived on this earth have to be classed together, and as all have been connected by the finest gradations, the best, or indeed, if our collections were nearly perfect, the only possible arrangement, would be genealogical. Descent being on my view the hidden bond of connection which naturalists have been seeking under the term of the natural system" (1859, pp. 448-449).

Moreover, this conclusion has important operational consequences, not just philosophical implications. If, for example, life's order records the connected pathways of a contingent and "messy" history, then a variety of formerly popular numerological schemes (like the "quinary system" based on organizing taxa into rigid and invariable groups of five for each higher level) cease to make scientific sense.

Over and over again, throughout the Origin, Darwin stresses that, for a large class of problems about species and interacting groups, answers must be sought in the particular and contingent prior histories of individual lineages, and not in general laws of nature that must affect all taxa in a coordinated and identical way (1859, p. 314):

I believe in no fixed law of development, causing all the inhabitants of a country to change abruptly, or simultaneously, or to an equal degree. . . . The variability of each species is quite independent of that of all others. Whether such variability be taken advantage of by natural selection, and whether the variations be accumulated to a greater or lesser amount, thus causing a greater or lesser amount of modification in the varying species, depends on many complex contingencies—on the variability being of a beneficial nature, on the power of intercrossing, on the rate of breeding, on the slowly changing physical conditions of the country, and more especially on the nature of the other inhabitants with which the varying species comes into competition.

Interestingly, one of the strongest modern critics of historicism in evolutionary science (Kauffman, 1993, as extensively discussed in Chapter 11), has explicitly identified the contingent status of the branching tree of life as his
Kauffman, of course, does not deny that the icon of branching correctly expresses the topology of life's history (at least for eukaryotic organisms). But he does argue, in the tradition of his intellectual mentor D'Arcy Thompson (see Chapter 11, pp. 1182-1208), that our Darwinian tradition places too much emphasis upon the particular history of a lineage to explain various evolutionary features that should, in his judgment, be encompassed under timeless and general laws as expressions of universal physics, and not explained as contingencies of unpredictable and individual pathways. Thus, although Darwin's own commitment to contingency has been underemphasized, or even unrecognized, by his later followers (largely in their own attempt to win more prestige for evolution under the misconception that science, in its "highest" form, explains by general laws and not by particular narrations), I am scarcely alone in identifying this central (and, in my judgment, entirely laudable) aspect of Darwin's view of life.

Kauffman, on the other hand, makes the same identification as a sharp critic. His single page of discussion, devoted to doubts about particularism rooted in the tree of life, cites a form of the word "branching" no less than twenty times, a sure mark of Kauffman's discomfort with this model, and his good insight about an appropriate target for criticism. Kauffman writes (1993, p. 5), for example:

The onset of evolutionism brought with it the concept of branching phylogenies. The branching image, so clear and succinct, has come to underlie all our thinking about organisms and evolution... With the onset of fullblown evolutionism and Darwin's outlook based on branching phylogenies, the very notion that biology might harbor ahistorical universal laws other than "chance and necessity" has become simple nonsense. Darwin's ascension marks a transition to a view of organisms as ultimately accidental and historically contingent. Our purposes have become analysis of branching evolutionary paths and their causes on one hand, and reductionistic unraveling of the details of organismic machinery accumulated on the long evolutionary march on the other.

It is important to recognize, and I'm sure that Kauffman and other critics would concur, that this debate between immanent vs. narrative styles of explanation contrasts different modes of factual knowing, and that both alternatives stand firmly opposed to trendy and nonsensical claims about the relativity of empirical "truth" in the light of social embeddedness for any transiently privileged intellectual procedure. When a champion of contingency (for the large chunk of nature properly falling under the aegis of narrative explanation) argues that he can explain with rigor after the fact what he could not have predicted in principle before the fact, he presents his best judgment about the empirical structure of historical complexity. Moreover, he does not confess thereby either any limitation imposed by an inferior form of science, or any irreducible subjectivity engendered by the admittedly ineluctable interaction of human perception and mentality with external "reality" in all efforts to understand nature's ways.

I would rather, and in the opposite direction, contend that our increasing willingness to take narrative explanations seriously has sparked a great potential gain, through admitting a pluralism of relevant and appropriate styles of explanation, in our accurate understanding of nature's wondrous amalgam of rulebound generalities and fascinating particulars. If I may return once more to Hatcher et al. (1907) on the extinction of ceratopsian dinosaurs (see p. 1331), the author's inarticulated assumption that explanation must flow from general principles of evolutionary biology and uniformitarian geology allowed no intellectual space beyond the most conventional proposals about vectors of organic progress generated by the extrapolation of natural selection in microevolutionary time, and on climatic change wrought by (at most) some intensification of ordinary geological processes. These presuppositions, in our current judgment, led Hatcher and his colleagues to factually incorrect conclusions based on false premises about inherent dinosaurian inferiority. In this case, I would argue that the introduction of narrative perspectives—particularly the idea that the K-T event should be explained as a singularity triggered by a bolide impact, and imposing its major effects fortuitously and exaptively upon particular features evolved in other contexts and "for" different reasons—has enlarged our armamentarium of potential explanations, and has surely led to a gain in factual understanding through an increased range of permissible scientific approaches.

As a first, and overly simplified, conclusion, one might then say that more adequate explanation in the evolutionary sciences demands that we titrate these two essential metacomponents of general theory and narrative particulars, or invariant predictability and contingent singularity, to achieve any satisfactory understanding of our primary subject matter—broad phenomena that embody sufficient regularity to exemplify the basic principles of theory, but that also engage, in their explicit reference to particular times, places and taxa, enough of the fascinating detail of historical events to ensure that even the most committed generalist will learn to appreciate, perhaps even to cherish, the antecedent details that ultimately fashion the empirical objects and events through which those basic principles become manifest.

I would not argue that all conceivable evolutionary questions must invoke enough historical particulars to require a large contingent component in their full explanation. After all, a paleontologist could claim that he only cares about mass extinction in general, and remains entirely indifferent to the question of why trilobites died in the Permian and ammonites in the Cretaceous. But what a heartless, gutless and uncurious soul he would then become. Indeed, James Hutton came pretty close to such total unconcern with the particular histories of geological sections in his "Theory of the Earth"—see Gould, 1987b. But then, Hutton's imperviousness to the fascination of history struck his friends and contemporaries as downright peculiar and mysterious; and the longstanding impression about his opacity and unreadability stems as much from this peculiarly desiccated focus, as from any supposed in-
adequacy in his prose style. Even in his own time, Hutton's friends felt that he could never prevail by his own wits, and that they would have to write "ponies" to make his ideas accessible. The most famous of these guides (Playfair, 1802), one of the great works in the history of geology in itself, succeeded largely by applying Hutton's theoretical ideas to explain puzzling particulars that historically minded scholars had long found anomalous.

In any case, and as a purely factual observation about the likes and habits of practicing scientists, hardly a natural historian, dead or alive, has ever failed to locate his chief delight in the lovely puzzles, the enchanting beauty, and the excruciating complexity and intractability of actual organisms in real places. We become natural historians because we loved those dinosaurs in museums, scrambled after those beetles in our backyard, or smelled the flowers of a hundred particular delights. Thus, we yearn to know, and cannot be satisfied until we do, both the general principles of how mass extinction helps to craft the patterns of life's history, and the particular reason why Pete the Protoceratops perished that day in the sands of the Gobi.

This perspective on mixing immanent and historical styles of scientific explanation in the evolutionary sciences, places me, in concluding this book, into an oddly paradoxical situation, exemplifiable in four statements. First, I have championed the cause, and equal claim, of contingency (particularly in Gould, 1989b and 1996a) to the point of my ready identification as a proponent of this position (and with no complaint on my part, and no feeling that my critics have been unfair in any oversimplification). Second, the standard strategy for invoking contingency in natural history employs a device of argument legitimately deemed restrictive in its negative criterion, and surely slated for abandonment as students of contingency develop their armamentarium of positive methods and preferential means of identification—but now accepted faute de mieux and in acknowledgment of current practice. That is, we tend to begin with a preference for explanation by predictability and subsumption under spatiotemporally invariant laws of nature, and to move towards contingency only when we fail. Contingency therefore becomes a residual domain for details left unexplained by general laws.

(Even so sophisticated a historian as McPherson (1988), studying so richly documented an episode as the American Civil War, grants the crucial Northern victory at Gettysburg to contingency largely because all classically proposed general reasons, either for the Union's triumph in the entire war, or for success in this key battle in particular, have conspicuously failed. This being said, the host of fascinating details then evinced to explain Northern success at Gettysburg—each apparently trivial, each unpredictable, and each eminently changeable before its occurrence by the tiniest of different circumstances—seems particularly impressive and conclusive as an example of contingent explanation, even for the most important events in history. Nonetheless—for this key point remains especially troubling, and should serve as a sharp spur to both thought and action—however satisfactory the final interpretation, we might never have gotten to contingency at all unless the alternative mode of explanation, so strongly privileged a priori, had failed. And I need hardly remind evolutionary biologists that such approaches, based upon prejudicially ordered preferences, remain dangerous because the strengths of our (frequently unconscious) assumptions, and the "flexibilities" of nature in seeming to bow to our biases (because we push too hard, and often unaware), may preclude any access to alternatives at all, as in our failure to consider fruitful and operational hypotheses that do not ascribe organismal traits to adaptation (Gould and Lewontin, 1979).)

Third, Darwin himself followed this strategy in the Origin, opening up an admittedly considerable space for contingency when he could not devise a testable generality, or when he felt that he had reached a level of uniqueness in detail that required a similar uniqueness in antecedent generating conditions. Fourth, and finally, I therefore find myself in what most of my friends and colleagues—but not my own assessment of my deeper interests and concerns—might construe as the anomalous position of trying to "win back" for general theory a substantial realm of macroevolutionary phenomenology that, in its failure to emerge predictably from microevolutionary principles of strict Darwinism, would be granted (under point two) to the very realm of contingency that I have tried so strenuously to promote and enlarge.

But I embrace this apparent paradox with delight. I have championed contingency, and will continue to do so, because its large realm and legitimate claims have been so poorly attended by evolutionary scientists who cannot discern the beat of this different drummer while their brains and ears remain tuned only to the sounds of general theory. But this book—entitled The Structure of Evolutionary Theory—does not address the realm of contingency as a central subject, and does fire my very best shot in the service of my lifelong fascination for the fierce beauty and sheer intellectual satisfaction of timeless and general theory. I am a child of the streets of New York City; and although I reveled in a million details of molding on the spandrel panels of Manhattan skyscrapers, and while I marveled at the inch of difference between a forgotten foul ball and an immortal home run, I guess I always thrilled more to the power of coordination than to the delight of a strange moment—or I would not have devoted 20 years and the longest project of my life to macroevolutionary theory rather than paleontological pageant.

So yes, guilty as charged, and immensely proud of it! The most adequate one-sentence description of my intent in writing this volume flows best as a refutation to the claim of paradox just above: This book attempts to expand and alter the premises of Darwinism, in order to build an enlarged and distinctive evolutionary theory that, while remaining within the tradition, and under the logic, of Darwinian argument, can also explain a wide range of macroevolutionary phenomena lying outside the explanatory power of extrapolated modes and mechanisms of microevolution, and that would therefore be assigned to contingent explanation if these microevolutionary principles necessarily build the complete corpus of general theory in principle. To restate just the two most obvious examples at the higher tiers of time exemplified in this chapter: (1) punctuated equilibrium establishes, at the second tier, a general speciational theory of cladal trending, capable of explain-
ing a cardinal macroevolutionary phenomenon that has remained stubbornly resistant to conventional resolution in terms of adaptive advantages to organisms, generated by natural selection and extrapolated through geological time; (2) catastrophic mass extinction at the third tier suggests a general theory of faunal coordination far in excess (see Raup's quantitative argument on p. 1326) of what Darwinian microevolutionary assumptions about the independent history of lineages under competitive models of natural selection could possibly generate.

In most general terms, and in order to form a more perfect union among evolution's hierarchy of structural levels and tiers of time, this revised theory rests upon an expansion and substantial reformulation of all three central principles that build the tripod of support for Darwinian logic: (1) the expansion of Darwin's reliance upon organismal selection into a hierarchical model of simultaneous selection at several levels of Darwinian individuality (gene, cell lineage, organism, clone, species and clade); (2) the construction of an interactive model to explain the sources of creative evolutionary change by fusing the positive constraints of structural and historical pathways internal to the anatomy and development of organisms (the formalist approach) with the external guidance of natural selection (the functionalist approach); and (3) the generation of theories appropriate to the characteristic rates and modalities of time's higher tiers to explain the extensive range of macroevolutionary phenomena (particularly the restructuring of global biotas in episodes of mass extinction) that cannot be rendered as simple extrapolated consequences of microevolutionary principles.

And yet, as an epilogue to this epilogue and, honest to God, a true end to this interminable book, I risk a final statement about contingency, both to explain the appeal of this subject, and to permit a recursion to my starting point in the most remarkable person and career of Charles Robert Darwin. Although contingency has been consistently underrated (or even unacknowledged) in stereotypical descriptions of scientific practice, the same subject remains a perennial favorite among literary folk, from the most snootily ärnone to the most rigorously vernacular—and it behooves us to ask why.

Our greatest novelists have reveled in this theme, as Tolstoy devoted both prefaces of War and Peace to explaining why Napoleon's defeat in Moscow in 1812 rested upon a thicket of apparently inconsequential and independent details, and not upon any broad and abstract claim about the souls of nations or the predictable efficacy of Russia's two greatest generals, November and December. And Wuthering Heights would have lost both its story line and existence if poor Heathcliff had not overheard, and utterly misunderstood, a conversation not intended for his ears in any case. And where would our occasionally philosophical movies find a subject if they couldn't mine the contingent fascinations of alternative and unrealized histories, either of little towns (It's a Wonderful Life) or of otherwise inconsequential people (the Back to the Future trilogy). And how could satire flourish if contingency movies couldn't generate an opposing parody (Groundhog Day), based upon a day that, in its repetition, cannot be changed at all, even by the most porten-

tous act of murder or suicide that its utterly frustrated protagonist can devise to extract himself from this nightmare of no novelty—until, of course, he finally understands the wisdom behind the only consistent definition that a philosophical determinist can possibly devise for liberty: Spinoza's conception of freedom as "the recognition of necessity."

If we then ask why literary, but not scientific, people have taken such a shine to contingency, I doubt that we need probe much beyond the most obvious of all reasons, the framework for the conventional stereotype of each discipline, and the putative difference between them as well. Science supposedly rests upon the objective generality of nature's laws and the utter insignificance of a practitioner's personality, or even his identity (beyond our vulgar and personal need to count coup, and also to count the prospects of future funding, prizes, privileges and parking places). Why else have we been trained to write our professional papers in the unstylish passive voice, as if "I didn't exist at all, and every datum "was discovered" in some disembodied manner? After all, although some particular somebody has to do it, the "it" is out there, and objectively knowable. Thus, it will be found, and within a narrow range of predictable time, largely dependent upon the development of technologies that initially make the discovery possible.

The equally silly and simplistic stereotype of the "other" side holds that literary people view the world as completely inchoate and unstructured (beyond the ideologically uninteresting, if practically portentous, compendium of observed regularities, suggesting, for example, that we will splatter if we fall off the roof of a 20-story building, or crunch if we happen to insert ourselves between a speeding vehicle and a concrete wall). Therefore, the argument continues, we make our own way in a subjective and unconstraining world. We alone are the architects and responsible agents of both our personal and our collective destinies.

As exaggerated as these characterizations may be, they do reflect some genuine cultural, and even partly justifiable, differences between two important, even noble, enterprises in their unculturated state. And, in this case, science could learn an important lesson from the literati—who love contingency for the same basic reason that scientists tend to regard the theme with suspicion. Because, in contingency lies the power of each person, no matter how apparently insignificant he may seem, to make a difference in an unconstrained world bristling with possibilities, and nudgeable by the smallest of unpredictable inputs into markedly different channels spelling either vast improvement or potential disaster.

And so, if Joshua Lawrence Chamberlain, former professor at Bowdoin College, and now commander of the gallant 20th Regiment of the State of Maine had not led one of the last successful bayonet charges in the history of warfare (because he had run out of ammunition and could only hope to prevail by a bluff of this sort), thus preventing the outflanking of the Union line (which could easily have been outflanked and overtaken, if the Confederates had grasped the desperate military situation of their adversaries), the South would probably have won at Gettysburg, leading to potential victory in the
war, a sundering of the United States, the balkanization of our continent, and the end (with markedly negative consequences for human history) of the world's most promising experiment in democracy. And if George Bailey had never been born (an alternative scenario that his guardian angel constructed for his consideration), the history of his town would have been equally sensible but altogether less pleasant for everyone actually loved by this apparently insignificant man. And so both the historical Mr. Chamberlain and the fictional Mr. Bailey (of America's most beloved movie) learned that one ostensibly small and meaningless life can make all the difference, sometimes for an entire world at a tipping point (in the admittedly grandiose and a bit extreme, but still not so utterly implausible, fable at the beginning of this paragraph), and more often for the few people whom we love and whom we yearn to serve as a source of comfort. The literati embrace contingency because no other theme so affirms the moral weight, and the practical importance, of each human life.

Thus, to end where this book began with Charles Darwin and his personal importance to our understanding of this grandest earthly enterprise, the tree of life, I must side with the literati and insist that my decision to focus this book on Darwin and the logic of his explanatory system for life's history and evolution's mechanism does not merely record an idiosyncratic or antiquarian indulgence. I will grant one point to my scientific colleagues and freely allow that if Charles Darwin had never been born, a well-prepared and waiting scientific world, abetted by a cultural context more than ready for such a reconstruction of nature, would still have promulgated and won general acceptance for evolution in the mid 19th century. At some point, the mechanism of natural selection would also have been formulated and eventually validated, perhaps by Wallace himself who might then have expanded his few pages of speculation, written during a malarial fit on Ternate, into the same kind of factual compendium that Darwin composed, and that guaranteed the triumph of this view of life.

So why fret and care that the actual version of the destined deed was done by an upper class English gentleman who had circumnavigated the globe as a vigorous youth, lost his dearest daughter and his waning faith at the same time, wrote the greatest treatise ever composed on the taxonomy of barnacles, and eventually grew a white beard, lived as a country squire just south of London, and never again traveled far enough even to cross the English Channel? We care for the same reason that we love okapis, delight in the fossil evidence of trilobites, and mourn the passage of the dodo. We care because the broad events that had to happen, happened to happen in a certain particular way. And something almost unspeakably holy—I don't know how else to say this—underlies our discovery and confirmation of the actual details that made our world and also, in realms of contingency, assured the minutiae of its construction in the manner we know, and not in any one of a trillion other ways, nearly all of which would not have included the evolution of a scribe to record the beauty, the cruelty, the fascination, and the mystery.

Yes, the Renaissance would have unfolded—indeed, Europe already bathed in its midst—if Michelangelo had never been born. But how much poorer would our world have been without the magnificent statue of Moses, furious and disconsolate as he holds the tablets of the law while his people dance about the golden calf, still presiding in the Church of San Pietro in Vincoli; and without the gigantic fresco of the Last Judgment, revealing all our blessed humanity in all our earthly sins, and still covering, in brilliant restoration, a full wall of the Sistine Chapel?

No difference truly separates science and art in this crucial respect. We only perceive a division because our disparate traditions lead us to focus upon different scales of the identity. The art historian looks right at Moses and knows the importance of its individuality. The scientist tends to gaze upon a world ready for evolution, and then discounts the centrality of a single, admittedly fascinating, individual named Charles Darwin. But if Darwin had never been born, wouldn't we have suffered the equivalent of a Renaissance without Moses or the Last Judgment—a biological revolution without the Origin of Species; without the invocation of Julia Pastrana, the bearded circus lady with two sets of teeth, to illustrate correlation of growth; without the Galapagos fauna to embody the principle of imperfection to prove the pathways of history; without pigeons to illustrate artificial selection; without barnacles to puncture half our pride with their dwarfed males upon the hermaphrodites.

Most of all, we would have experienced the same biological revolution without the stunning clarity, illustrated by wonderfully apposite metaphors, of a complex central logic so brilliantly formulated, and so bristling with implications extending nearly forever outward, at least well past our current reckoning. In this alternate world, we would probably be honoring a different and far less compelling founder by occasional visits to a statue in a musty pantheon, and not by constant dialogue with a man whose ideas live, breathe, challenge, taunt, and inspire us every day of our lives, more than a century after his bones came to rest on a cathedral floor at the foot of whatever persists in the material being of Isaac Newton.

We would be enjoying an evolutionary view of life, but not the specific grandeur of "this view of life." What can be more ennobling than a factual reality—the uniquely actualized result among innumerable potentials that did not obtain the most precious privilege of emergence into concrete existence? And what a stunning piece of good fortune, that this actuality came to us with all the grace, the moral weight, and the intellectual power of Darwin's particular struggles and insights, clothing the structure of his thought in that apotheosis of human achievement—wisdom, which the Book of Proverbs, citing the same icon that Darwin would borrow more than two millennia later, called Erz Chayim, the tree of life. "Length of days is in her right hand," for "she is a tree of life to them that lay hold upon her; and happy is every one that retaineth her."